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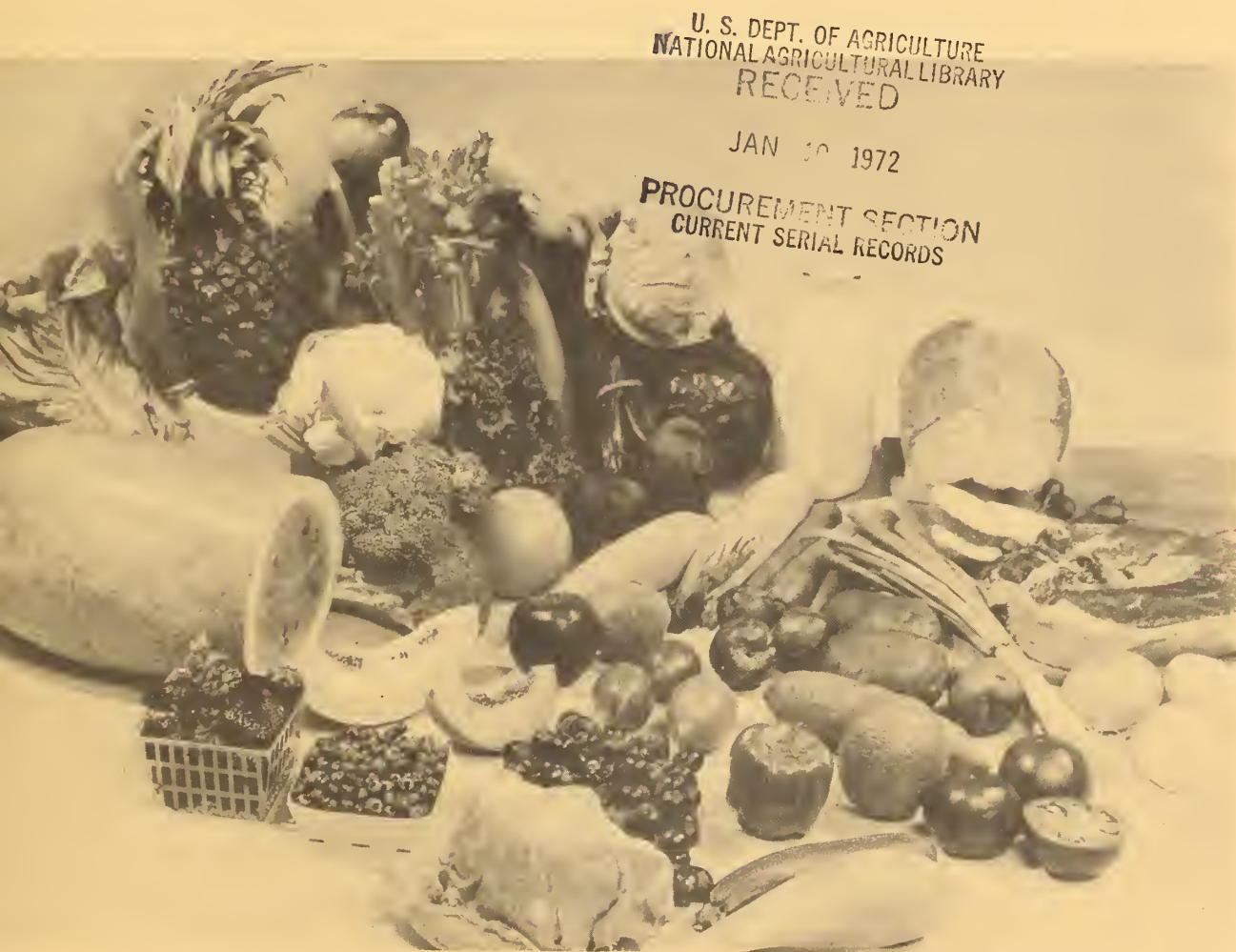
PROGRESS REPORT

☆-☆

of the

MARKET QUALITY RESEARCH DIVISION  
MARKETING AND NUTRITION RESEARCH

JULY 1, 1971



Agricultural Research Service  
UNITED STATES DEPARTMENT OF AGRICULTURE





This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation.

The summaries of progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1970, and June 30, 1971. Current agricultural research findings are also published in the monthly USDA publication Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, United States Department of Agriculture, Hyattsville, Maryland.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and/or Federal agencies before they can be recommended.

**CAUTION:** Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife -- if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the United States Department of Agriculture or an endorsement by the Department over other products not mentioned.



Issued December 1971



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PROGRESS REPORT  
OF THE  
MARKET QUALITY RESEARCH DIVISION  
MARKETING AND NUTRITION RESEARCH  
July 1, 1971

INTRODUCTION

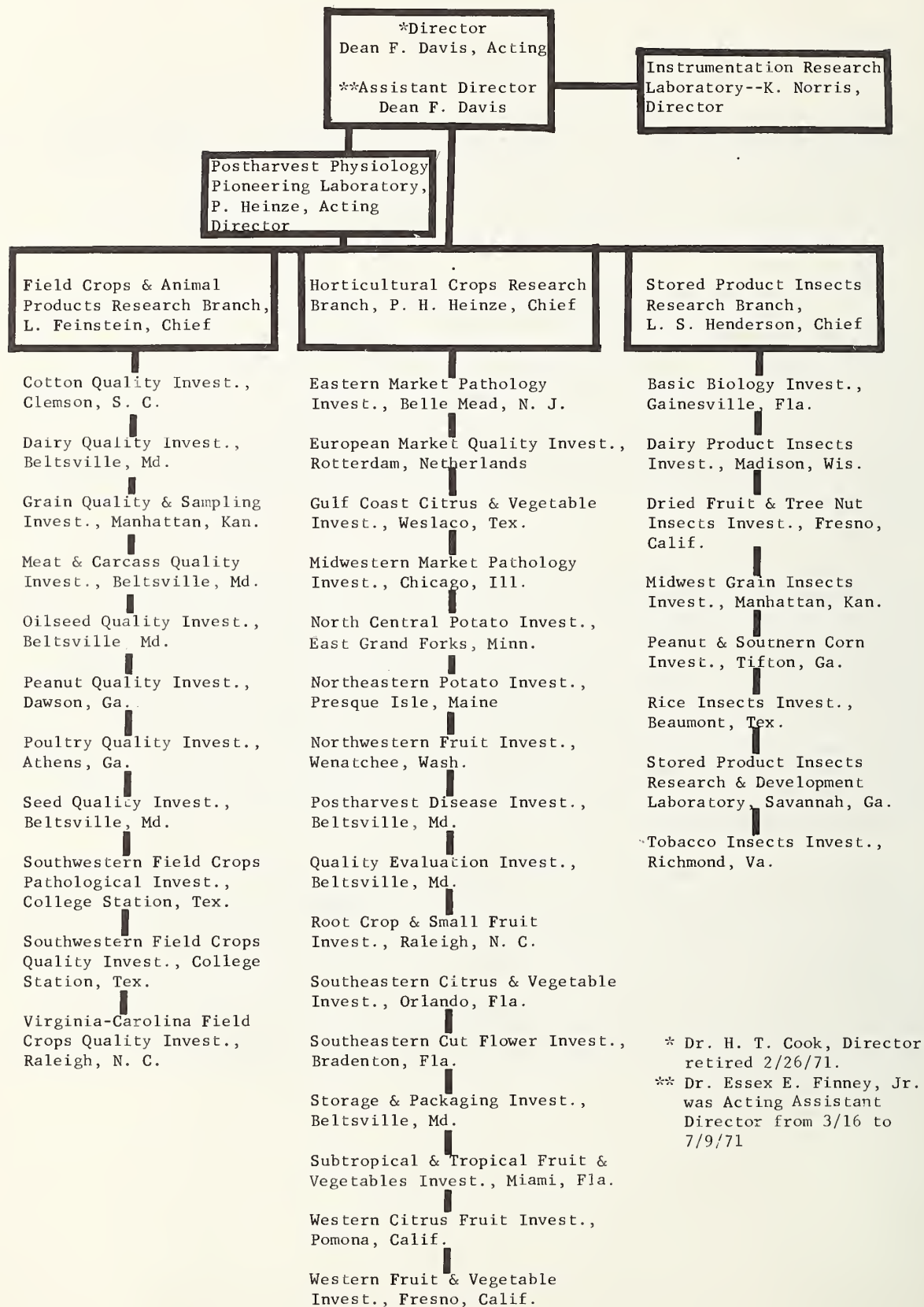
The research of the Market Quality Research Division is concerned with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport, and distribution of agricultural commodities, and the development of new methods and devices for measuring and characterizing quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. About 30 scientists are located at Beltsville, Maryland, including personnel of the Instrumentation Research Laboratory, Postharvest Physiology Pioneering Research Laboratory, Field Crops and Animal Products Research Branch, and Horticultural Crops Research Branch. There are 28 field stations located throughout the country; 13 are located at state universities or branch experiment stations and 2 are in terminal markets. One is located in the port of Rotterdam, Netherlands, and emphasizes methods of improving the quality of United States perishables in the European markets.

Although a large variety of excellent quality fresh and processed agricultural products are retailed at reasonable prices throughout the year, there is need for further research on methods to reduce spoilage and waste during storage, transportation, and distribution, and to improve methods for measuring and defining quality. Stored product insects and market diseases still destroy large amounts of commodities regardless of costly preventive measures. There is urgent need for new methods for controlling insects and diseases that will not create health or environmental hazards due to pesticide residues. Automated objective methods of quality evaluation are increasingly needed to make possible rapid reliable grading and inspection of large quantities of produce under modern packing, handling, and transporting conditions.

An appreciable amount of the Division's research is related to the effective performance of the service divisions of the Consumer and Marketing Service responsible for standardization, inspection, and grading of agricultural commodities, and the regulatory and control divisions of the Animal and Plant Health Service responsible for preventing entry of foreign pests into the United States and spread of domestic pests from quarantined areas. The Division also works closely with industry and other Government agencies on various problems relating to agricultural commodities in the marketing channels, including exports to the valuable European markets.

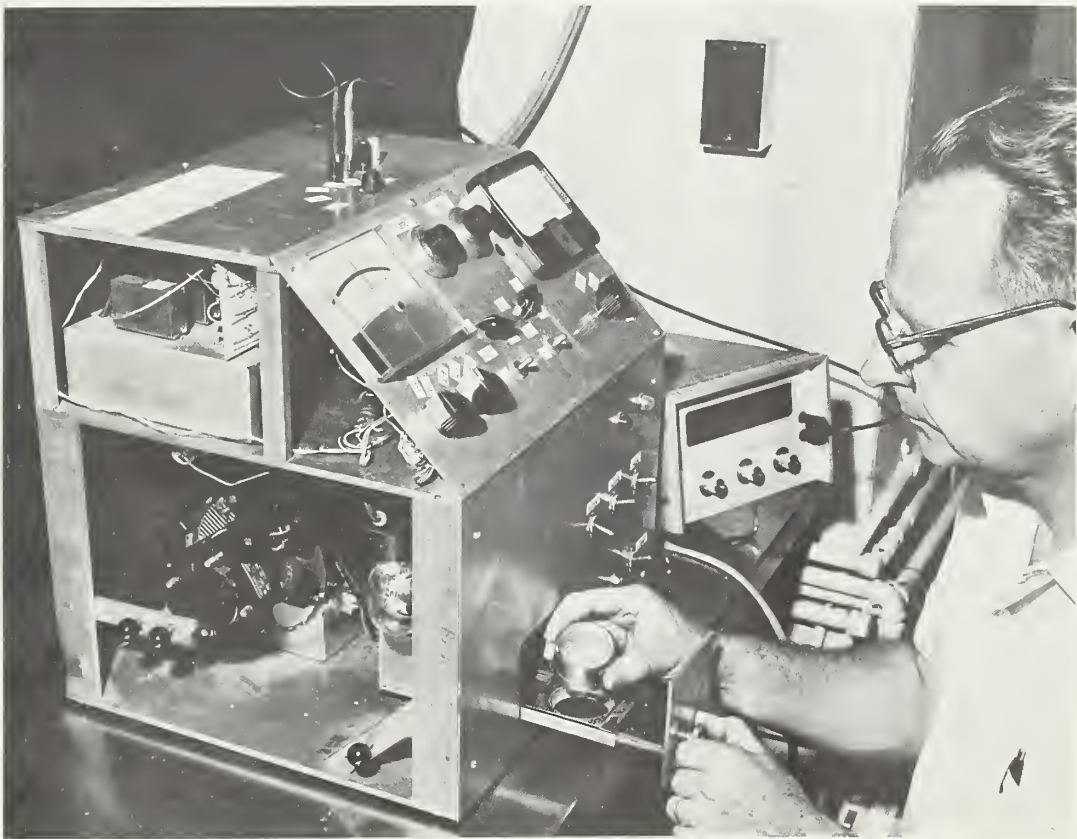
## MARKET QUALITY RESEARCH DIVISION





## EXAMPLES OF PROGRESS

New Analyzer for Soybean Marketing.--A research model of an electronic instrument which determined the oil, protein and moisture content of soybeans in less than 5 minutes has been developed. Two versions of the research instrument will be constructed by commercial instrument manufacturers and evaluated during the 1971 harvest season. Since no methods were available for rapid determination of oil and protein, soybeans are marketed with no regard for the value of these components. The new instrument could have great impact on the marketing of soybeans. For example, the new technology could provide farmers an opportunity to receive the additional 15¢ per bushel soybeans having 22% oil content are worth compared with those having 20%, and the additional 20¢ per bushel beans containing 44% protein are worth compared with those containing 40% protein. Such a marketing system would be more equitable and the farmer would be paid for the protein or oil present in his commodity. The buyer could select soybeans with specific quality attributes desired for a given end use and pay only for that attribute.



Karl Norris works at the laboratory research model of the new soybean oil-protein-moisture analyzer.

New Method for Identifying Microorganisms.--Detection of microorganisms of public health significance is complicated and very time consuming (5-7 days for Salmonella). Current methods of testing can result in delays in shipment of meat pending the outcome of biological identification procedures. Pyrolysis-gas-liquid-chromatography (PGLC) was used to numerically characterize species variation among members of the Aspergillus glaucus group. Analysis of pyrochromatograms indicated PGLC would seem a more definitive approach to the numerical evaluation of the similarity or affinity between strains of the A. glaucus and A. flavus groups, and the ordering of these strains into taxa on the basis of their affinities because of the large number of characters which can be used. Serotypes of salmonellae on meat were successfully identified by PGLC, but more rapid means of evaluating peaks, representing fragments of bacterial molecules, needs to be developed. Advantages of the PGLC detection method are: (1) tests can be completed in a few hours instead of the several days now required; (2) the equipment is semiautomatic and less training is required for technicians; (3) procedures are simplified and result in a cost savings.

Quick Test for Corn Dust.--Fire, explosions, and air pollution are sometimes associated with stored corn containing large quantities of dust. Present tests for chaff and foreign matter in grain, however, indicate only roughly the dust content. A new test was developed which measures dust accurately and rapidly. This test may help establish standards to judge complaints by foreign purchasers that our grain is sometimes too dusty. It could also be used to assess the working environment in grain storage facilities and establish specific tolerances for dust content for protecting the health of workmen and eliminating possible dangers of fire and explosion. The test, developed specifically for use with corn, costs about 10¢ to make and requires little training or experience. Necessary equipment can be readily obtained for about \$250 and set up at any location where grain is handled.

New Test for Peanut Maturity.--The determination of peanut maturity continues to be a problem for the peanut industry. Current methods are not completely reliable. A new and simple method was developed for estimating maturity in peanuts. Green farmers stock peanuts are extracted with methanol as soon as they are harvested. Then the extract is filtered and its light transmittance measured in a colorimeter at a wavelength of 450 mμ. The darker the extract, the more mature are the peanuts. Extract with a light transmittance of about 48% shows that it came from fully mature peanuts.



Improvement of Rice Inspection Procedures.--Milled rice inspection and classification according to United States standards has historically been and continues to be largely subjective in nature. Improvements and standardization of inspection procedures depends greatly on the development of accurate, reliable instrumentation and procedures which will facilitate objective measurement of important quality factors. Significant research was accomplished in 2 specific areas, color sorting and sizing. Conventional color sorters, which use reflected light, are not satisfactory for rice grading. An electro optical device was developed and interfaced with a conventional sorter to facilitate simultaneous sorting of milled rice on the basis of reflected and transmitted light. In the area of sizing broken kernels of milled rice, factors which affect the results obtainable from the conventional rice sizer were studied in order to arrive at recommendations for improving the accuracy and repeatability of this device.

Difference Meter for Sorting Maturity Levels of Tomatoes.--Tomatoes are sorted repeatedly by the prepacker to separate "breaker" fruit from mature green fruits. Resorting of the fruit requires voluminous amounts of labor and reduces the shelf life due to additional handling. By use of a 4-filter difference meter containing narrow band interference filters the differences in optical density of mature green fruit were measured. According to the degree of differences, the level of maturity was determined and date of ripening predicted. A high speed electronic sorter based on the 4-filter multiwavelength difference meter would have the following advantages over standard sorting methods: (1) reduced handling costs; (2) marketing of specified fruit maturities; (3) improved delivery schedule for United States and export shipments because of uniform ripening; and (4) higher quality tomatoes for the consumer.

CA Extends Storage Life of Peaches and Nectarines.--Recent laboratory tests showed that several varieties of peaches and nectarines keep at least twice as long in controlled atmospheres with low oxygen concentration as in air. The controlled atmosphere reduces decay, delays ripening, and maintains firmness longer than in air. Maximum storage for highly perishable peaches and nectarines is about 2 to 3 weeks at 32° F. If stored longer, fruit fails to ripen satisfactorily when moved to higher temperatures; flavor deteriorates and the fruit breaks down internally. The best atmosphere discovered for peaches and nectarines is 1% oxygen with 5% carbon dioxide, which maintains quality in storage for up to 6 weeks. Fruit stored in this manner has better flesh color and flavor, less decay, and is juicier than fruit stored in air. Losses during storage and transport are estimated at 4%. Reducing losses by 3% with controlled atmosphere storage would save an estimated \$4 million annually. In addition the marketing period is extended and the possibility of export is improved.

Bulk Shipping of Precut Seed Potatoes.--Cooperative research with the Colorado Agricultural Experiment Station has resulted in a new concept for shipping seed potatoes. A 180,000 pound Conditionaire carload of precut suberized seed shipped from Colorado to Florida arrived at destination with 0.5% decay for the variety Norchip and 4.8% decay for Sebago. Stands from the precut seed were 54% better than from seed cut at time of planting. Yields were 180% greater from precut seed than they were from seed cut at the time of planting. Precut seed has the potential to save \$1.4 million in seed cost through improved stands and yield for Florida growers.

New Fungicides Give More Effective Cantaloupe Decay Control.--The search for better control of postharvest surface molds on cantaloups prompted work of screening fungicides for this purpose. Tests showed that triarimol, benomyl and thiabendazole reduced surface and stem scar molds of Alternaria and Diplodia organisms more than the standard commercial treatment. Each of these fungicides, when applied to melons as a 30 second dip at 135° F., resulted in more salable melons, extended the shelf life and improved the shipping quality.

Prevention of Sunburn in Crenshaw Melons.--High quality Crenshaw melons are easily injured by solar radiation. Annual losses from sunburn range from 1/4 to 1/3 of the crop, which amounts to a direct loss of about \$600,000. Whitewashing these melons 1 to 2 weeks before harvest prevents or greatly reduces sunburn. The commercial feasibility of this technique is being investigated in cooperation with growers and applicators. Its use on other varieties of melon is also being researched.

New Thin Layer Chromatography Method for Thiabendazole Residues in Citrus.--Thiabendazole (TBZ) is used to control decay in citrus during storage and shipping. Analysis of TBZ residues is necessary to study applications and to ensure compliance with regulatory requirements. The standard procedure for TBZ requires lengthy liquid-liquid partitions to remove interfering substances. Occasionally extraneous citrus constituents which interfere are not completely removed, particularly with dried citrus pulp used for cattle feed. A thin layer chromatography (TLC) method was developed for ethyl acetate strippings of intact citrus, ground citrus, juice, oil and cattle feed. A simple 2 step partition is required before TLC cleanup for ground fruit, juice, oil and cattle feed but direct TLC of strippings of intact fruit is possible. TBZ is separated from extraneous citrus constituents by TLC, the TBZ is then eluted with acidified methanol, and quantitative measurements made on a spectrophotofluorometer. The TLC method is accurate and specific for TBZ.

Removal of Mineral Deposits from Apples.--The use of over-tree sprinklers for irrigating apple trees has increased greatly during the past few years. In parts of north central Washington, however, the use of water with high carbonate content results in unsightly mineral deposits on the fruit. The usual wash methods employed in packinghouses do not remove these deposits and affected fruits are rejected by the inspectors as unclean. Thus, fruit otherwise suited for fresh market use must be sold at a much lower price for processing. Since the deposits are predominantly carbonates their removal with an acid appeared to be the best approach. The question of corrosion of equipment resulted in the selection of acetic acid for removing the carbonates since it is not as active chemically as the mineral acids. A concentration of 0.5% acetic acid in the dumper tank or in the washer was found to remove most of the minerals from the surface of the fruit thereby making the fruit suitable for the fresh market.

Improved Black Light Trap for Navel Orangeworm.--To aid in the fight against the insect pests that annually destroy and contaminate a large amount of our tree nut and dried fruit crop, a battery operated black light trap was designed and built. The new trap was found to be more effective than the conventional line powered traps in trapping the peach twig borer and the navel orangeworm. The navel orangeworm causes serious problems in stored almonds and figs as well as in the orchard. The new trap is less expensive to build and to operate than the traps presently available and the amount of servicing is negligible. The 2.5 volt DC battery will operate the trap 24 hours per day for 5 months to 2 years. Costs of parts, including battery, is \$27.50. The traps are used to detect and sample populations of the insects in the orchards where the nuts and fruits become infested. Information obtained by trapping is useful in determining when and where to apply control measures against the insects and for studying the biology and ecology of the pests.

New Mothproofers Alternatives for DDT.--Research has uncovered several alternatives for DDT for use in mothproofing stored woolens. DDT is no longer recommended for such use. Costly damage is inflicted by carpet beetles and clothes moths that take their toll on expensive products after much time, effort, and money have been spent in processing the wool and making the items. Upholstered furniture, piano felts, carpeting, suits, dresses, sweaters, and coats are some of the selected foods of these insects. The loss of wool products caused by these fabric pests and the cost of temporary protective measures against the insect attack amounts to millions of dollars annually. After research on several hundred experimental chemicals, quaternary ammonium compounds, Gardona and Penick SB-1382 were found to be most effective. All have low toxicity to mammals and should not accumulate in the human body with repeated exposure. The results of this research have been publicized and commercial interests are now conducting developmental studies which should lead to utilization of the new materials.

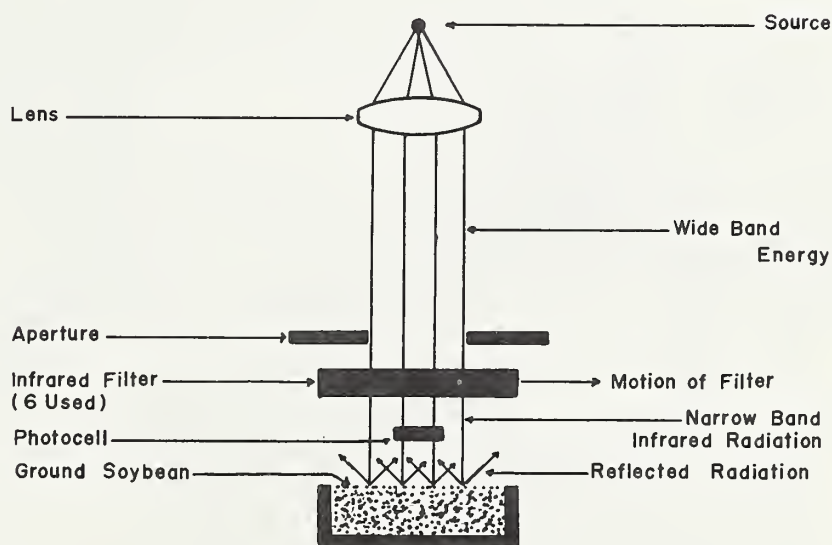
New Bags Protect Prunes for 6 Months or More.--The California prune industry spends about \$3 million annually for insect control but still experiences about \$230,000 worth of damage annually. A newly developed bag should reduce these losses considerably. This bag consists of 2 plies, one of polyethylene and one of cellophane. A treatment of 5 mg. pyrethrins and 50 mg. piperonyl butoxide per square foot is applied in the adhesive layer that binds the 2 films together. The chemical is thus contained so that it will not rub off onto the prunes. A small amount, however, does migrate through the packaging film. Approval for use of the chemicals in 2 pound prune bags has been granted by the Food and Drug Administration.



# NEW ANALYZER FOR SOYBEAN MARKETING

## SITUATION:

- ▷ SOYBEAN NOT GRADED ON COMPOSITION
- ▷ CHEMICAL TESTS REQUIRE ABOUT 12 HOURS
- ▷ LABORATORY FACILITIES REQUIRED
- ▷ TRAINED PERSONNEL NEEDED FOR TESTING



## PROGRESS:

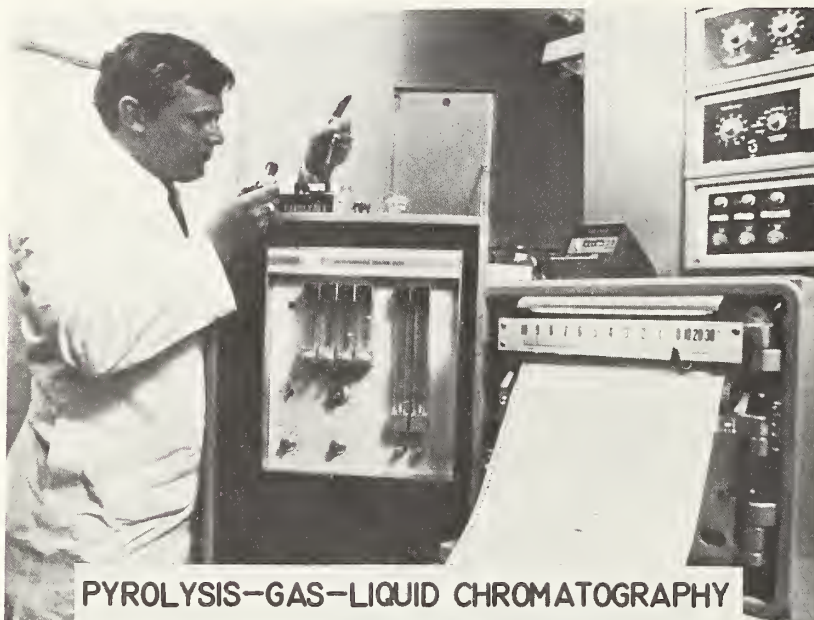
- ▷ AUTOMATIC SOYBEAN ANALYZER DEVELOPED
- ▷ PROTOTYPE INSTRUMENTS AVAILABLE
- ▷ COMMERCIAL FIRMS TO FIELD TEST IN 1971

## ADVANTAGES:

- ▷ PROTEIN, MOISTURE, AND OIL CONTENT BASIS OF GRADING
- ▷ TEST IS SIMPLIFIED
- ▷ CAN BE DONE IN 5 MINUTES
- ▷ MORE EQUITABLE RETURNS TO ALL PARTIES IN MARKETING SYSTEM

# NEW METHOD

## FOR IDENTIFYING MICROORGANISMS



PYROLYSIS-GAS-LIQUID CHROMATOGRAPHY

### SITUATION:

- ▷ BIOCHEMICAL TEST REQUIRES DAYS
- ▷ PROCEDURES COMPLICATED
- ▷ TECHNICIANS NEED EXTENSIVE TRAINING

### ADVANTAGES:

- ▷ TEST COMPLETED IN HOURS
- ▷ EQUIPMENT SEMI-AUTOMATIC
- ▷ LESS TRAINING REQUIRED
- ▷ SIMPLIFIED PROCEDURES
- ▷ COST SAVINGS

# QUICK TEST FOR CORN DUST

## PROBLEM:

- ▷ FIRES, EXPLOSIONS, AND AIR POLLUTION CAN BE CAUSED BY DUST IN STORED CORN.
- ▷ PRESENT TESTS ONLY GIVE ROUGH ESTIMATE OF DUST CONTENT.



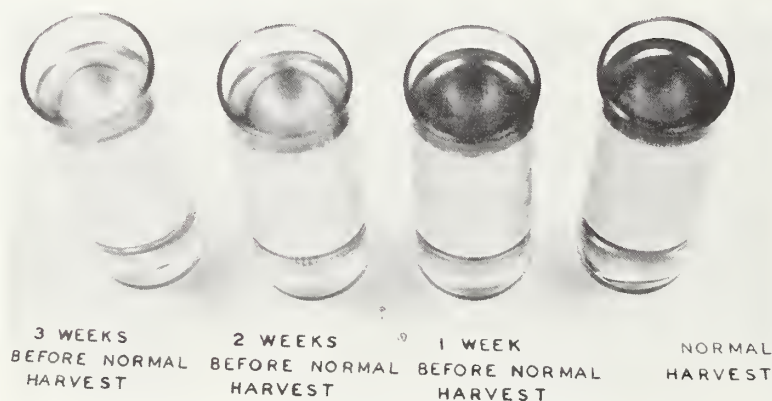
## ADVANTAGES:

- ▷ MEASURES DUST CONTENT ACCURATELY AND RAPIDLY
- ▷ INEXPENSIVE – ABOUT 10 CENTS PER TEST
- ▷ NEEDED EQUIPMENT INEXPENSIVE AND CAN BE SET UP IN ANY LOCATION.
- ▷ MAY HELP ESTABLISH DUST STANDARDS FOR EXPORTED CORN
- ▷ TEST MAY HELP IN ESTABLISHING SPECIFIC DUST TOLERANCES

# NEW TEST FOR PEANUT MATURITY

## PROBLEM:

- ▷ INDUSTRY NEEDS TO CLASSIFY PEANUTS ON BASIS OF MATURITY
- ▷ CURRENT TEST METHODS ARE NOT COMPLETELY RELIABLE



## ADVANTAGES OF NEW TEST PROCESS:

- ▷ ESTIMATES MATURITY MORE ACCURATELY
- ▷ RESULTS AVAILABLE IMMEDIATELY AFTER HARVEST
- ▷ TEST EASILY PERFORMED
- ▷ ONLY ORDINARY LABORATORY EQUIPMENT NECESSARY
- ▷ MAY PERMIT SPECIAL TREATMENT OF IMMATURE LOTS BEFORE MOLDS AND/OR MYCOTOXINS DEVELOP.

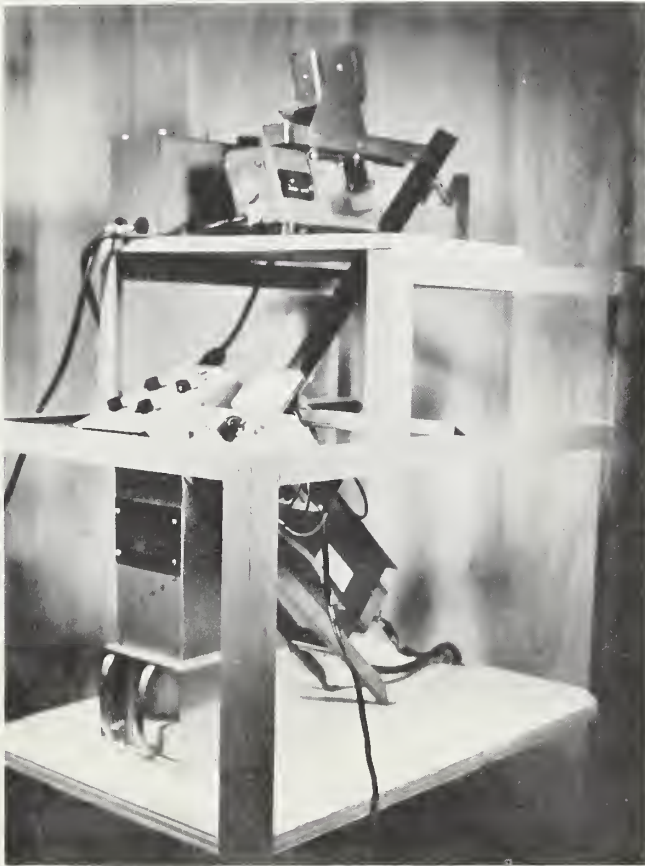


# IMPROVEMENT

## OF RICE INSPECTION PROCEDURES

### PROBLEM:

▷ CURRENT MANUAL METHOD IS SUBJECTIVE



▷ METHOD NOT CONDUCTIVE TO  
STANDARDIZATION

▷ METHOD REQUIRES TOO MUCH  
TIME PER SAMPLE

▷ CONVENTIONAL COLOR SORTER:  
NOT SATISFACTORY

### ADVANTAGES:

- ▷ MODIFIED COLOR-SORTER GREATLY IMPROVES SEPARATION CAPABILITY
- ▷ ACCURACY AND REPEATIBILITY OF SIZING GREATLY IMPROVED
- ▷ TESTING PROCEDURES MORE OBJECTIVE
- ▷ IMPROVED TESTING FACILITATES EXPORTATION OF RICE

# DIFFERENCE METER FOR SORTING MATURITY LEVELS OF TOMATOES

## SITUATION:

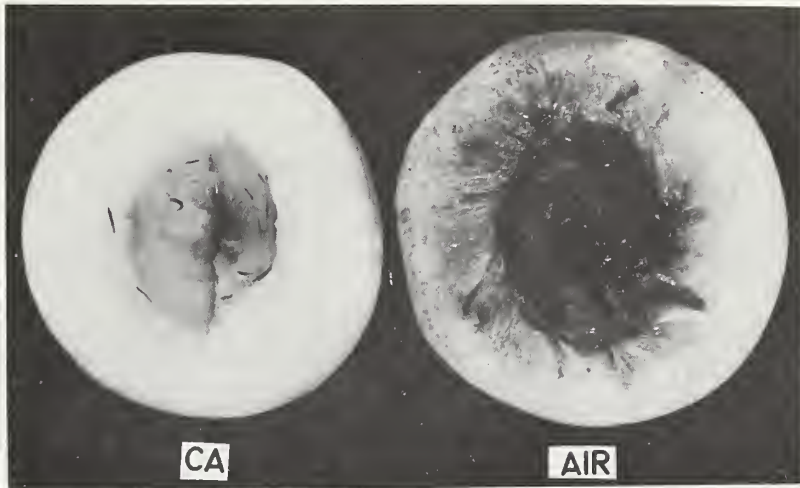
- ◆ REPEATED HAND SORTING REQUIRED
- ◆ RIPENING DATE UNPREDICTABLE
- ◆ ADDITIONAL HANDLING
- ◆ SHELF LIFE REDUCED
- ◆ LOW QUALITY FRUIT

## ADVANTAGES:

- ▷ LABOR SAVING
- ▷ BETTER QUALITY FRUIT
- ▷ IMPROVE DELIVERY SCHEDULE
- ▷ IMPROVE EXPORT MARKET POTENTIAL
- ▷ A POTENTIAL 39 MILLION DOLLAR SAVINGS



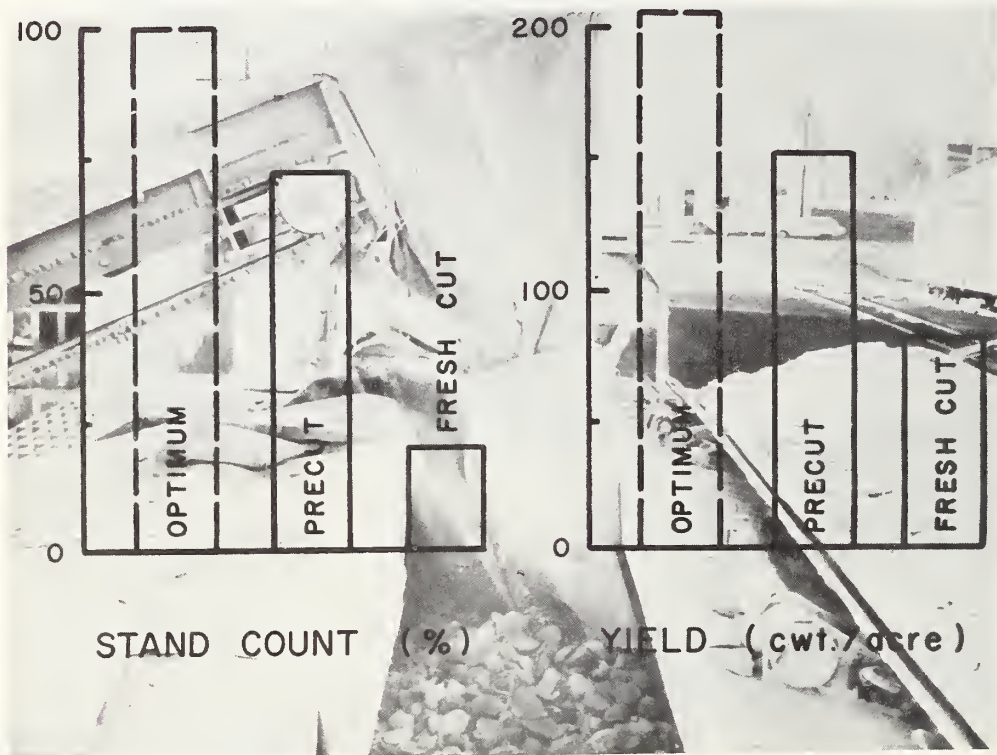
# CA EXTENDS STORAGE LIFE OF PEACHES & NECTARINES



## ADVANTAGES:

- ▷ MAINTAINS QUALITY IN STORAGE UP TO 6 WEEKS
- ▷ BETTER FLESH COLOR
- ▷ EXTENDS MARKETING PERIOD
- ▷ BETTER FLAVOR
- ▷ LESS DECAY
- ▷ JUICIER FRUIT
- ▷ POTENTIAL 4 MILLION DOLLAR SAVINGS

# BULK SHIPPING OF PRECUT SEED POTATOES

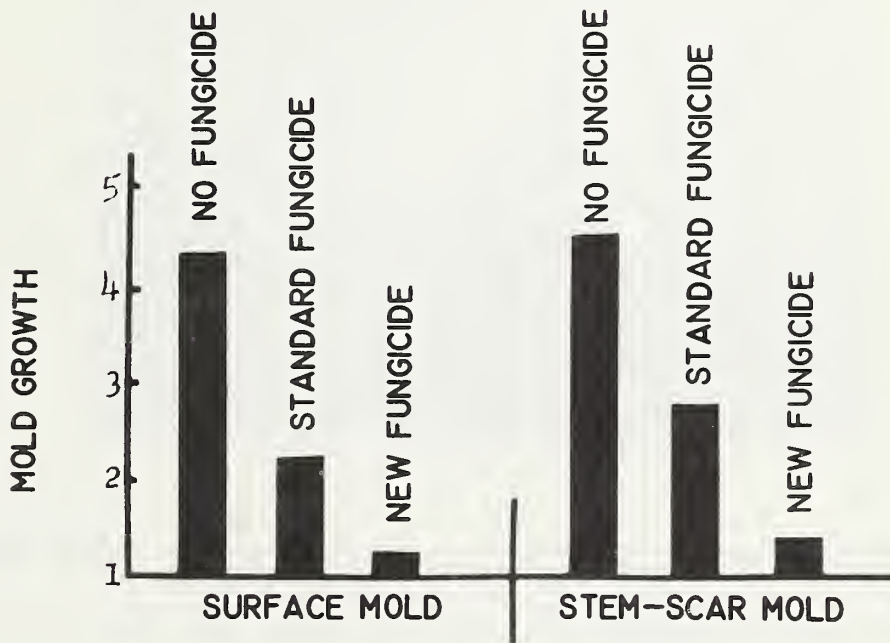


## ADVANTAGES:

- ▶ UTILIZES SEED POTATO GROWER'S WORK FORCE AND EQUIPMENT MORE EFFICIENTLY
- ▶ REDUCES GROWER'S LABOR AND EQUIPMENT COSTS
- ▶ REDUCES LOSSES FROM SEED PIECE DECAY
- ▶ IMPROVES STANDS, YIELDS, AND INCOME



# NEW FUNGICIDES GIVE MORE EFFECTIVE CANTALOUPE DECAY CONTROL

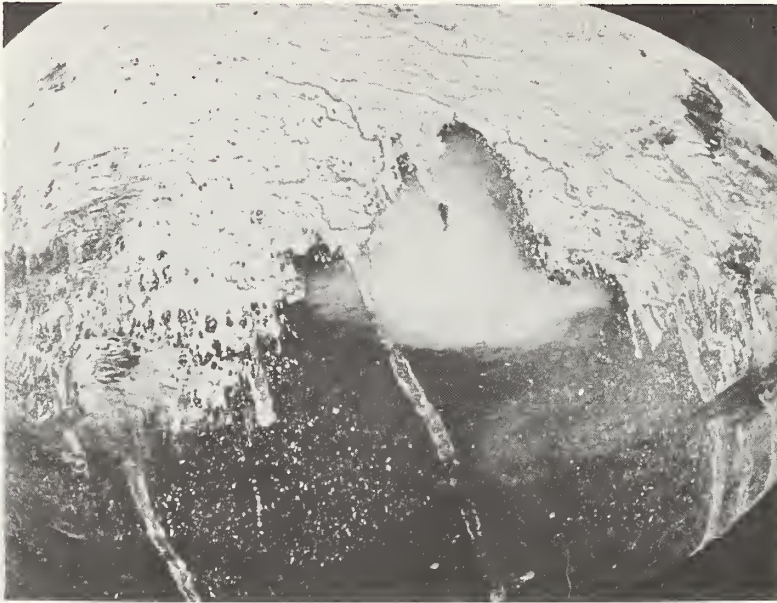


## ADVANTAGES:

- ▷ MORE SALABLE MELONS
- ▷ EXTENDED SHELF LIFE
- ▷ IMPROVED SHIPPING QUALITY
- ▷ REDUCED LOSSES

# PREVENTION OF SUNBURN

## IN CRENSHAW MELONS



### PROBLEM:

■ HIGH QUALITY MELONS INJURED BY SOLAR RADIATION

■  $\frac{1}{4}$  -  $\frac{1}{3}$  CROP LOST

### SOLUTION:

▷ WHITEWASH 1-2 WEEKS BEFORE HARVEST

PREVENTS SUNBURN

### ADVANTAGES:

✓ REDUCES LOSSES

✓ 600,000 DOLLAR SAVINGS

# NEW THIN LAYER CHROMATOGRAPHY (TLC) METHOD FOR TBZ RESIDUES IN CITRUS



- 1 TBZ  
STANDARD
- 2 ORANGE  
STRIPPING
- 3 GROUND  
ORANGE
- 4 TBZ  
STANDARD

## SITUATION:

- ✓ MUST COMPLY WITH PESTICIDE RESIDUE REGULATIONS
- ✓ STANDARD METHOD LENGTHY — COMPLICATED

## ADVANTAGES:

- ▷ METHOD CAN BE USED FOR INTACT FRUIT, GROUND CITRUS, JUICE, OIL, AND CATTLE FEED
- ▷ METHOD ACCURATE AND SIMPLIFIED
- ▷ SPECIFIC FOR TBZ
- ▷ ANALYSIS COST REDUCED

# REMOVAL OF MINERAL DEPOSITS FROM APPLES



TREATED

NON-TREATED

## PROBLEM:

■ MINERAL DEPOSITS ON FRUIT

■ USUAL WASH METHODS WILL NOT REMOVE

■ FRUIT REJECTED

■ MUST BE SOLD AT LOWER PROCESSING PRICE

## SOLUTION:

▷ USE 0.5% ACETIC ACID IN WASH WATER OR DUMP TANK – DEPOSIT REMOVED

## ADVANTAGE:

✓ FRUIT SOLD AT HIGHER PRICE

✓ ANNUAL SAVINGS OVER 100,000 DOLLARS



# IMPROVED BLACK LIGHT TRAP—

## FOR NAVEI ORANGEWORM

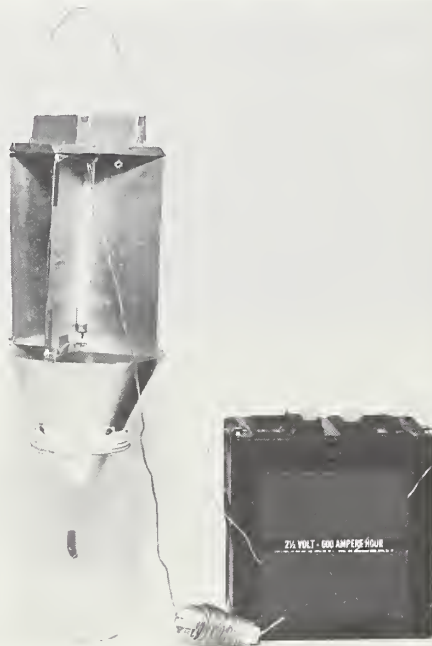
### PROBLEM:

- ▷ MOTHS INFEST ALMONDS IN ORCHARD
- ▷ CONTINUED NUT DAMAGE DURING STORAGE

### SOLUTION:

- ▷ MORE EFFECTIVE PORTABLE BLACK LIGHT TRAP DEVELOPED BY MQ

INSECT LIGHT TRAP



### ADVANTAGES:

- ▷ NEW TRAP MORE EFFECTIVE FOR SAMPLING MOTH POPULATION
- ▷ LIGHTWEIGHT
- ▷ INEXPENSIVE
- ▷ FEATURES MAKE TRAP MORE SUITABLE FOR USE IN ORCHARDS

# NEW MOTHPROOFERS

## ALTERNATIVES FOR DDT

### PROBLEM:

- ▷ DDT NO LONGER RECOMMENDED FOR STORED WOOLENS
- ALTERNATIVES NEEDED.



### SOLUTION:

- ▷ NEW SAFER CHEMICALS FOUND WHICH GIVE EFFECTIVE CONTROL

### ADVANTAGES:

- ▷ CONTROL AS EFFECTIVE AS DDT
- ▷ HAVE LOW MAMMALIAN TOXICITY
- ▷ SHOULD NOT ACCUMULATE IN HUMAN BODY AS DDT WILL.
- ▷ REDUCE LOSSES WHICH AMOUNT TO MILLIONS OF DOLLARS ANNUALLY.

# NEW BAGS PROTECT PRUNES

— FOR 6 MONTHS OR MORE

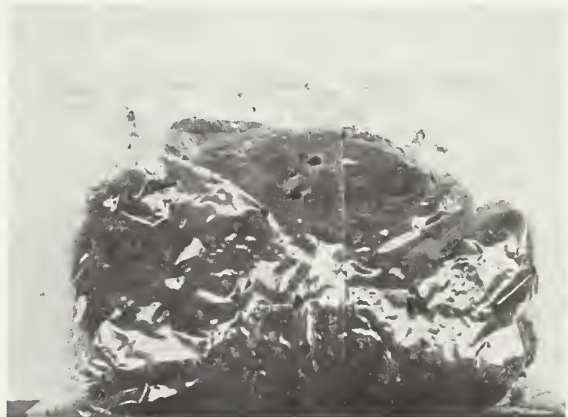
## PROBLEM:

✓ INDUSTRY SPENDS 5 MILLION DOLLARS ANNUALLY

FOR INSECT CONTROL YET SUFFERS QUARTER MILLION DOLLAR DAMAGE.



NEW TYPE BAG  
Insect Free



STANDARD TYPE BAG  
Insect Infested

## SOLUTION:

▷ USE MQ-DEVELOPED 2-PLY INSECT-RESISTANT BAG

## ADVANTAGES:

- ▷ PROTECTS PRUNES FROM INSECT DAMAGE
- ▷ REDUCES INSECT CONTROL COSTS
- ▷ INCREASES CONSUMER ACCEPTANCE
- ▷ APPROXIMATE QUARTER MILLION DOLLAR ANNUAL SAVINGS.

## CITRUS AND SUBTROPICAL FRUITS

## Quality Maintenance in Storage

Controlled atmosphere storage.--Satisfactory progress is being made on controlled atmosphere (CA) storage of some subtropical fruits. Although citrus CA research has not progressed as rapidly, it is now beginning to show more promising results.

Florida grapefruit.--Midseason and late Florida grapefruit can be stored for a limited time at 50° F. but lower storage temperatures result in rind breakdown. The presence of atmospheric carbon dioxide (CO<sub>2</sub>) reduces and, in some instances, prevents rind breakdown at temperatures lower than 50°. Theoretically, the storage life of grapefruit can be extended by lowering the storage temperatures and rind breakdown avoided by simultaneously introducing CO<sub>2</sub> into the storage atmosphere.

In tests at Orlando, grapefruit was subjected to 10% and 20% CO<sub>2</sub> for 1 day and 8 days at 40° F., then stored in air for 5 weeks at the same temperature, and finally held at 70° for 2 weeks. After this holding period, the fruit which had been subjected to 10% CO<sub>2</sub> for 1 day had 14% rind breakdown whereas, fruit exposed for 8 days had 2% breakdown. Fruit subjected to 20% CO<sub>2</sub> for 1 day had 2% rind breakdown whereas, an 8-day exposure completely controlled the disorder (0%). The control fruit held in air had 20% rind breakdown. In subsequent tests, fruit subjected to 20% CO<sub>2</sub> for 2 weeks and then stored for an additional 6 weeks at 40° in air had no rind breakdown. Some of the CO<sub>2</sub>-treated fruit was unusually firm after holding for 7 and 14 days at 70°.

Avocados.--One hundred percent of Booth 8 avocado fruit stored in controlled atmosphere (2% oxygen + 10% carbon dioxide) at 40° and 45° F. for 20 or 40 days was in acceptable condition after softening in air at 70°. The overall appearance of fruit stored in CA for 20 or 40 days at 40° was slightly better than the appearance of fruit stored at 45°. After 60 days, 70% of the fruit stored at 45° ripened with acceptable quality. Storage in CA at 40° for 60 days resulted in uneven ripening and slight chilling injury with accompanying decay development. Decay became severe in both air and CA storage at 50°. Internal and external chilling injury developed in avocados stored in air for 40 or 60 days and all fruits were unacceptable.

Limes.--The use of "Purafil" to aid in purification of the atmosphere in storage chambers containing air, 10% oxygen + 10% CO<sub>2</sub> and 10% oxygen + 0% CO<sub>2</sub> had no consistent effect on juice content of Persian limes after



storage for 20, 40 and 60 days at 45° F. Juice content was the lowest after storage in 10% oxygen + 10% CO<sub>2</sub> for 20, 40 and 60 days. Loss of green peel color was slightly greater in chambers containing "Purafil" with either air or 10% oxygen + 10% CO<sub>2</sub>.

Bananas.--Bananas responded satisfactorily when stored under reduced atmospheric pressures and could be ripened satisfactorily on removal. The use of benomyl caused stem injury during storage but mold growth was meager.

Common storage.--Lemons - Research results at Pomona indicate that it might be feasible to extend the normal marketing period of early season Arizona lemons. Early season lemons stored under conditions of high relative humidity were in a marketable condition after 8 months of storage at 57° F. with less than 1% decay. In contrast, storage of late season Arizona lemons was terminated after 3 months because of excessive decay. Early season lemons retained more green color and were of better appearance after 8 months of storage than late season lemons after 3 months of storage.

#### Quality Maintenance during Transport

Domestic.--A combination of ventilation and refrigeration was compared to continuous refrigeration in test truck shipments of citrus from the Rio Grande Valley to Los Angeles. Results of three tests indicate that the combinations of ventilation and refrigeration resulted in lower product temperatures than continuous refrigeration.

Export.--Three test shipments of citrus from the Rio Grande Valley to Europe were loaded break bulk in reefer storage to evaluate effect of different cartons on fruit quality. Measurements of carton distortion showed the single wall (glued end panel, 275 pound test bottom and 250 pound test top) to be superior to the double wall (stitched, 200 pound test bottom and top) type. The single wall cartons had less end bulge, bottom sag and top compression. However, the double wall type had less side bulge. It was found that with both carton types used, considerable bruising subsequently resulting in decayed fruit, occurred if the cartons were layered more than eight high.

## Postharvest Physiology

Flavor impairment.--Controlled atmosphere storage has been found to cause flavor impairment to oranges in California tests. This impairment was studied by determining the endogenous volatiles emanating from intact fruits. Ethanol and acetaldehyde production increased as the oxygen level decreased from 5 to 2 to 0 percent. No differences in volatile production were found at oxygen levels of 10, 15 and 20 percent. Ethanol and acetaldehyde content of juice increased during storage at an oxygen level as high as 15 percent.

Degreening.--Preharvest applications of ethephon (2-chloroethylphosphonic acid) at concentrations of 200 to 500 ppm were effective in inducing degreening in Robinson, Lee, Nova and Dancy tangerines and Hamlin oranges. This response reduced the need for postharvest degreening, and fruit showed less decay in storage. Some loosening of fruit and in some cases fruit drop resulted from application of these concentrations. Leaf abscission was not serious except on Robinson and Lee tangerines with applications at 300 to 500 ppm.

Preharvest applications of up to 750 ppm ethephon had no effect on degreening or abscission of Bearss lemon fruit. This failure to respond was reduced by detaching the fruit, indicating a controlling effect of the tree on the fruit. Tests on other varieties showed that this "tree effect" was a general response in citrus although it was less evident in some varieties than in others.

Postharvest applications of ethephon were effective in inducing degreening in Bearss lemons, Robinson, Lee and Dancy tangerines, Marsh grapefruit and Hamlin oranges. Concentrations of 500 to 1000 ppm appeared to be most effective and the response was greater at 80° than at 60° F.

In Texas degreening studies, both Marrs oranges and Ruby Red grapefruit exhibited increasing chlorophyll losses with increasing ethrel concentrations. In any given ethrel concentration, there was more chlorophyll retention in fruit held at 70° than at 85° F. Greater chlorophyll loss occurred in fruit degreened by the standard ethylene degreening than in fruit degreened with ethrel.

Fundamental research.--Related P.L. 480 research in Israel has shown that  $10^{-4}$  to  $10^{-8}$  M concentrations of applied abscisic acid (ABA) has a distinct inhibitory effect on indole acetic acid (IAA)-induced ethylene production as well as on the natural ethylene production of pea seedlings. However, it appears that ABA has little or no effect on kinetin-induced ethylene production in the seedlings. Ethylene production by citrus peel plugs was not affected by IAA and ABA.

Antibodies specific to gibberellic acid (GA) and IAA have been produced. Antibodies to ABA have recently been produced by injecting a hormone-protein conjugate to rabbits. Adoption of the immunoassay method to plant extracts is now in progress. It appears that GA can be detected from crude extracts but IAA needs more purification before it can be detected. Concentrations of  $10^{-15}$  M kinetin, IAA, and ABA did not interfere with detection of pure GA ( $10^{-4}$  to  $10^{-8}$  M) in the immunoassay.

Biological activity of a covalent GA-protein conjugate is being studied in an attempt to simulate the possible naturally occurring protein-bound gibberellins. GA conjugated to bovine serum albumin (GB-BSA) has GA-like activity in the barley half-seeds bioassay.

### Postharvest Disease Control

Export tests.--Export test shipments with Florida grapefruit showed that a flood application of 3000 ppm thiabendazole (TBZ) or 3000 ppm TBZ plus sodium orthophenylphenate (SOPP) was the best fungicidal treatment for reducing decay during the export transit period. The addition of two biphenyl pads to each carton had little additional effect on the reduction of decay. Small experimental shipments of Temple and Murcott Honey oranges arrived with no rind breakdown, less than 3 percent decay and good flavor.

Preliminary export test shipments with California Valencia oranges showed that various levels of TBZ in wax did not prevent sporulation of Penicillium during the export transit period.

In simulated export shipping tests, wax applications of TBZ at 1 to 2 ppm residue on citrus fruit provided better control of Penicillium decay than SOPP foam wash (1 to 2 ppm residue) or wax application (7 to 8 ppm residue) or biphenyl pads. Biphenyl reduced fungus sporulation and fruit soilage better than 1 to 2 ppm TBZ but 5 to 6 ppm TBZ residue was superior to biphenyl except on lemons where biphenyl was especially effective. Combinations of fungicides were more effective than individual fungicides. Wax application of a combination of TBZ (1 to 2 ppm) and SOPP (7 to 8 ppm) was as effective or superior to biphenyl and SOPP (1 to 2 ppm). The combination of TBZ, SOPP and biphenyl provided the best Penicillium decay, sporulation and soilage control.

Texas grapefruit.--In grapefruit storage tests, green mold (Penicillium digitatum) decay reduction indices of the more effective tested fungicides were: 0.2% benomyl; 1.0% G-20072 (5-aceto-8-hydroxyquinoline-sulfate); and a combination of 0.2% benomyl and 0.75% G-20072 all gave 100% control; 0.3% benomyl gave 97.1% control; 0.2% benomyl plus 1.0% 2-aminobutane gave 98.6%

control; and 0.2% benomyl plus 0.2% TBZ gave 90.3%. The fungicides were tested as dried-on and rinsed treatments on artificially inoculated fruit. Generally, the non-rinsed fruit had less decay than the rinsed fruit.

Florida citrus.--Washing Bearss lemons prior to either ethylene degreening in a coloring room or natural degreening at 60° F. resulted in less Diplodia stem-end decay than washing comparable fruit after either method of degreening. Fifty degrees was the best long-term storage temperature for Bearss lemons. Chilling injury resulted at 33° and 40°, while excessive decay and orange color developed during and following 60° storage. TBZ was more effective in reducing postharvest decay of degreened lemons, oranges and mandarins when applied immediately after harvest and prior to degreening. Effectiveness was not materially reduced by subsequent washing after degreening.

Mangos.--Grove spray treatment of Keitt mangos with benomyl fungicide during the growing season resulted in reduction of stem-end and anthracnose decay by one-third to one-half after storage in air or controlled atmosphere at 50° F., and after subsequent softening in air at 70°. All controlled atmospheres tested were superior to storage in air.

Market losses.--Lemon losses in the Chicago market for retail packout were 2.27% from pathogenic rots and 0.51% from physiological disorders. Losses on the retail shelf were 0.88% from pathogenic rots and 0.18% from physiological disorders. Consumer losses amounted to 1.58% from pathogenic rots.

### Quality Evaluation

Maturity determination.--Changes in fruit ethanol during the growing season affords a means for determination of optimum fruit conditions for storage. Research at Orlando has shown that the ethanol content of juice of citrus fruit during the growing season increased more rapidly as the fruit approached maturity than did the increase in solids-acid ratio. This additional measure of maturity was observed in Hamlin, Pineapple, Valencia and Temple oranges and in Marsh grapefruit. During controlled atmosphere storage of fruits, the ethanol content of juice increased with decreasing oxygen concentration. Waxed fruit consistently had higher ethanol than non-waxed fruit. Changes in the substrates citrate, malate, and pyruvate and in the enzyme pyruvic dehydrogenase, malic enzyme, and alcohol dehydrogenase in juice vesicles during storage were small compared to the increase in ethanol. Citrus alcohol dehydrogenase had a definite but limited control over nicotinamide-adenine dinucleotide redox ratio in orange juice vesicles.



## COTTON

## Determination of Quality

## Methodology

Fiber breaking strength and mass.--Previous work showed that not only is it possible to measure the acoustic pulse generated by a breaking cotton fiber, but also that the shape and magnitude of the pulse is a function of the physical properties of the fiber. An analytical model was developed predicting the magnitude of the acoustic pulse from known fiber physical properties. The model is being studied to improve its relationship with experimental results. Certain variables, including fiber shape, fiber fineness, and breaking gauge length showed no effect on the magnitude of the acoustic pulse. Evidence indicated that pulse magnitude is a function of the strength and elongation of fiber. This may provide a basis for a strength and elongation test for single cotton fibers. It is desirable in certain fiber and yarn tests to measure mass of a bundle of cotton fibers by measuring dielectric properties of the bundle. A limitation in using this technique has been the variation in dielectric properties of different types of fibers. Results were accumulated showing variation in dielectric properties to be related to moisture content of fibers and variation may be eliminated by drying fibers to a sufficiently low level of moisture.

Fiber mass measured.-- Two methods of measuring the mass of a bundle of cotton fibers were studied: (1) The use of alpha radiation and (2) the use of an optical system and parallel light. The alpha radiation system provided a measurement more highly correlated with actual weight of the bundle than did the optical method. However, there are problems involving the long-term stability of the measuring system.

Fiber length analyzer.--A theoretical solution based on areas under a fibrogram was developed to determine the variability of fiber length in a sample of cotton fibers. In tests made on an experimental Length Analyzer, using 16 different cottons, a very good relationship was found between Length Analyzer length-variability and the 50/2.5% span length and uniformity ratio as determined by the Digital Fibrograph. A significant, though poorer, relationship was found between Length Analyzer length-variability and length-variability determined by the Suter-Webb array method.

New test for sugar content.--A method to categorize cottons according to sugar content was developed. The basis of the method is the reaction

of the sugars on cotton with potassium ferricyanide. The test is simple and does not require either elaborate equipment or special training for technicians. Several hundred samples can be tested per day.

## Instrumentation

Automatic Fibrosampler.--An automatic Fibrosampler developed under contract with Special Instruments Laboratory, Inc., is currently being evaluated in MQ's fiber testing laboratory. The autosampler was designed to operate with an improved, previously-developed comb for use with the Digital Fibrograph. Operation of the sampler requires only the insertion of the comb into a slot and placing the cotton sample onto a flat, perforated plate. Total time to prepare a specimen is approximately 10 seconds. The results of the evaluation indicate that the sampler performs satisfactorily with the exception of the cleaning device that strips the specimen brush. The brushes operate automatically and are self-cleaning. Currently, the mechanism must be cleaned periodically by hand to avoid chokes. The manufacturer is constructing an attachment to eliminate this problem. The Fibrosampler will be evaluated under production-line testing conditions as soon as the laboratory evaluation is completed.

Fiber Strength Analyzer.--A procedure was developed for modifying the Cotton Fiber Strength Analyzer so an amount reading, highly related to the fiber bundle weight, can be obtained. The reading was obtained automatically when the tapered beard routinely prepared for the instrument was used. Measurements can also be made on a bundle of parallel fibers similar to the beard used in the Pressley method of measuring fiber strength. Limited evaluation of a prototype tester resulted in a technique to remove the effect of micronaire reading which, in the past, has biased strength readings on this instrument. Preliminary results indicated that strength measurements using a parallel beard on the Strength Analyzer were more highly correlated with Pressley strength than strength measurements using the tapered beard. Results using parallel beard were more variable than those from tapered beard.

New combs for Digital Fibrograph.--New combs were developed for use in obtaining a representative cotton specimen for measurement on the Digital Fibrograph. The combs are made from nylon, with a row of steel needles attached to collect the specimen. The arrangement of needles is different than on the old combs. The needles, or teeth, are finer and closer together, and provide a more uniform specimen than the wider, coarser teeth on the old combs. A thorough evaluation of the new combs will be

completed before they are used on the high speed cotton fiber testing lines. Data currently available indicate that the combs performed satisfactorily on the automatic Fibrosampler.

Production line fiber testing system evaluated.--As a part of the continuing study of methods to implement the use of instruments to measure cotton quality, a production-line cotton fiber-testing system was operated for 1 week at Hayti, Missouri, under the supervision of the Cotton Division, C&MS. Among the cottons tested were 157 samples on which full-scale Pilot Plant spinning studies were conducted. Samples from the same studies were tested in a previous phase of the evaluation. A comparison of results from the two investigations indicated that the repeatability of the production-line instruments was very good except for the Length-Strength Analyzer. After an extensive review of the data collected and the procedure used, it appeared that the calibration procedure used to set the test level of the Length-Strength Analyzer was inadequate and possibly the cause of the poor repeatability.

#### Cotton Characteristics

Fiber properties related to processing properties.--To determine relative market value of cottons with specific fiber properties, accurate and precise relationships between fiber properties and spinning performance and yarn quality are needed. Work reported in the literature has touched on the subject, but inconsistent and incomplete results are obvious. Furthermore, only cottons with limited combinations of fiber properties have been used under the same experimental conditions. A series of five spinning studies was planned to provide a foundation for establishing the desired relationships. Two of the spinning studies have been approved for processing in the Pilot Spinning Plant. Cottons with a wide range in fiber properties will be used to spin several yarn sizes in order to stratify the results into meaningful groups to form the relationships. All cottons have been purchased for the first study; a search for cottons to be used in the other series is underway.

Processing quality of low micronaire cottons.--In marketing, discounts are levied against cottons with micronaire readings outside the 3.5 to 4.9 range. Small percentages of these cottons are blended with cottons within the 3.5 to 4.9 micronaire range to form mill mixes. Feasibility of using larger portions of these discounted cottons in mill mixes was studied. The sensitivity of processing quality to fiber quality was accentuated by producing low twist yarns. Use of more than 5% cotton with micronaire reading as low as 3.2 caused both processing and quality problems, including dyeing problems. Up to 33% 5.2 micronaire reading cotton could be used without causing processing or quality problems.



## Improving Manufacturing Practices

Optimum spinning quality.--After a lengthy delay because of difficulty in locating cotton with the desired fiber properties, the spinning phase of a cooperative project with Clemson University was begun. Optimum spinning performance of two different drafting systems, using two different roving twist multipliers and two different yarn numbers is being studied. Only a part of the results are available for analysis; however, it appears that different roving twist multipliers require different spinning tensor settings for optimum spinning performance.

Quality of Pima cottons.--Preliminary analysis of spinning data for long staple Pima cottons grown in New Mexico in 1970 showed results similar to those obtained on the 1969 crop. Manufacturing waste was approximately 3% less for cottons harvested by spindle pickers than for those harvested by strippers. Comber noils were approximately 8.5% less for early harvest, spindle picked cottons than for late-harvest, stripped cottons. The spindle picked cottons had higher fiber and yarn quality than the stripped cottons. A regression equation was developed for predicting tensor setting for optimum spinning of 80s combed yarns for use in MQ's Clemson processing laboratory. This equation was developed from data obtained from our combed yarn fiber properties study. To obtain sensitivity, Pilot Plant ends down studies are currently done with low yarn twist, which unfavorably biases quality evaluations involving shorter cottons. To evaluate cottons properly on a standard basis, an adjustment for differences in the effect of yarn twist is needed. Data are being analyzed to develop an equation for adjusting spinning ends down to a desired level of yarn twist. Generally, lint cleaners (saw and mill types) used on roller-ginned, long-, and extra-long staple cottons reduced fiber length. Cottons ginned with lint cleaners had approximately 2% less manufacturing waste than cottons ginned with no lint cleaners.

Spinning performance relative to grade.--Cottons from three grades (Strict Low Middling, Low Middling, and Strict Good Ordinary) with no grass and no bark in most cases had higher spinning performance and yarn quality than cottons of the same grades which were reduced to these grades because of grass and bark. Use of crush rolls during carding generally resulted in improved spinning performance as compared to cotton carded without crush rolls. The most improvement occurred in the lower cotton grades.

Optimum drafting force.--Drafting-force measurements made at various cradle settings on a MagneDraft spinning system indicated trends in processing quality similar to trends obtained by the Duo Roth TruSet drafting system. The level of drafting force for optimum spinning was dependent upon processing organization and differences in the draft control system. The standard MagneDraft system requires a higher level of drafting force for optimum spinning than the DuoRoth TruSet system. Two improved Spin-Draft testers were designed, and drawings and specifications were submitted for contract bids for construction. A patent, No. 3,577,600, was obtained on an apparatus for rapid automated measurement of drafting force variability (Spin-Draft Tester).

Causes of lap-ups studied.--Results of continuing research into the causes of lap-ups in spinning of roller-ginned cottons indicated that high knife-to-roller pressure and high temperature in the knife-roller contact area are related to increased lapping in spinning. Lap-ups were higher for cottons ginned on an 8" laboratory gin than for those ginned on a 15" commercial gin. Second picking cottons lapped more than first picking cottons.

### Marketing of Cotton

New marketing system based on instrument measurements of fiber quality proposed.--To market cotton on instrument measurements of fiber quality, each quality factor must be measured rapidly enough to meet marketing needs. In addition, the contribution of each quality factor must be determined to arrive at its worth in a marketing system. A manuscript entitled "Cotton Classification System for a Quality Minded Industry--Proposed Use of Instrument Measurements for Marketing" was developed, indicating one approach to a system for marketing cotton on instrument measurements. The objectives of the manuscript are to (1) Point out the need for an improved system for marketing cotton, (2) present an approach for using instrument measurements in marketing cotton, (3) indicate how the proposed system would benefit the cotton industry, (4) provide a realistic set of guidelines as to the relative use value of various cotton qualities, and (5) improve communications among the various segments of the cotton industry, which is vital to orderly and effective marketing.



## CUT FLOWERS AND ORNAMENTALS

## Quality Maintenance in Storage

Controlled atmosphere storage.--Controlled atmosphere (CA) storage research results have indicated that some ornamentals can be successfully stored in CA but others might be injured by the atmospheres.

Gladiolus.--The addition of 10% ethylene to 20% oxygen-3% carbon dioxide (CO<sub>2</sub>) atmosphere of gladiolus corms caused earlier emergence and longer root development. The preservative 8-hydroxyquinoline citrate plus sucrose (8-HQC + S) did not overcome deleterious effects of 1 ppm fluoride on cut flowers.

Gardenia.--Blooms which were held for 3 weeks at 0° C. (32° F.) were in the best condition when stored in an atmosphere enriched with 15% carbon dioxide (CO<sub>2</sub>). Those held in 20% CO<sub>2</sub> were whiter but slightly injured, while those held in atmospheres with less than 15% CO<sub>2</sub> were of poorer quality. Blooms held in 1% or 21% oxygen did not differ in quality.

Chrysanthemum.--Cuttings stored at 0° C. (32° F.) for 1 month in an atmosphere with 5% or more carbon dioxide (CO<sub>2</sub>) showed visible foliar injury, which increased upon planting. Neither lower CO<sub>2</sub> nor 1 ppm ethylene in the storage atmosphere had an effect on the cuttings. Root formation was not affected by CO<sub>2</sub> levels up to 10%.

Common storage.--Asters cut in the tight bud stage (40 mm diameter) and held in 300 ppm 8-hydroxyquinoline citrate plus 3% sucrose opened as well as flowers cut as "open buds" (90 mm diameter). Bud-cut flowers were successfully stored for 3 weeks at 0° C. (32° F.) and opened in the preservative 8-hydroxyquinoline citrate plus sucrose as well as freshly harvested buds.

## Quality Maintenance during Transit

Chrysanthemums shipped by air.--Four air shipments from California of "Albatross" and "Yellow Albatross" chrysanthemums cut as buds (60-70 mm diameter) and open blooms were evaluated at Beltsville, Md. Buds placed in water after arrival never opened to normal usable size. Buds placed in 2% Everbloom Oasis (3 oz/gal), or in a preservative of 2% sucrose with 200 ppm

8-hydroxyquinoline citrate opened to normal size in 4 or 5 days at 23.5° C. (74° F.). The opened buds then had a vase life similar to that of chrysanthemums opened on the plant. Buds stored dry two weeks at 0° C. (32° F.) after shipment also opened satisfactorily in the preservative solutions but deteriorated slightly more rapidly than non-stored buds.

Three air shipments from Florida of bud-cut standard chrysanthemums were evaluated for vase life both with and without prior storage. Buds stored 12 or 20 days at 0° C. (32° F.) in Florida before opening deteriorated more rapidly after shipment than non-stored buds. Chlorosis and subsequent drying and death of foliage was more severe with 0.5% sucrose than with 2.0% sucrose in the vase solutions.

Controlled atmosphere for shipping.--Laboratory and simulated shipping tests with carbon dioxide (CO<sub>2</sub>) dry ice generators resulted in 15 to 20% CO<sub>2</sub> in carnation shipping containers. The dry ice also lowered the temperature of the flowers from 13° C. (55° F.) to 7° C. (45° F.).

### Postharvest Physiology

Preservatives for cut flowers.--Chrysanthemum - More water was absorbed and greater percent retained by chrysanthemum stems held in 8-hydroxyquinoline citrate plus sucrose preservative than in water. Leaf removal, darkness, or lanolin cover on leaves decreased water absorption by bud-cut flowers. Bud-cut flowers opened in the preservative as well as buds held intact and opened on the plant.

Poinsettia.--Leaf removal from cut poinsettia stems did not affect bract longevity, but preservatives greatly improved it.

Carnation.--Bud-cut flowers (20 mm) held in 400 ppm 8-hydroxyquinoline citrate plus 3% sucrose opened as well in 3 to 4 days as buds held on the plant.

Cattleya orchids.--Cut orchids exposed to 30 parts-per-billion (ppb) ethylene for 24 hours at 15° C. (59° F.) showed injury symptoms 24 hours after the treatment and blooms exposed to 10 ppb had visible injury 48 hours after treatment.

## Postharvest Disease Control

Heat treatment for rust control.--Geraniums - In cooperative tests with the California State Nursery Service and the University of California Extension Service, geranium cuttings of 12 varieties were heat treated. Preliminary results indicate that control of rust could be achieved with hot, moist air at 38° C. (100° F.) for 48 hours. In addition, the tests indicate that eradication of the rust might be possible with a 50° C. (122° F.), 90-second hot water dip without damage to the cuttings.

## DAIRY PRODUCTS

## Determination of Quality

Composition of imitation milks.--A total of 13 imitation milk formulations were obtained and compared with two samples of dry whole milk. The 13 samples appear to represent all that are available at the present time since virtually no imitation milks are now being sold at the retail level. Some representative results to date as compared with whole milk are: Protein 0.76-3.67% vs. 3.25% for whole milk; carbohydrates and stabilizers 4.50-7.62% vs. 4.55% for whole milk; fat 2.65-4.35% vs. 3.54% for whole milk; and ash 0.29-0.73% vs. 0.71% for whole milk. Similar variations in composition with regard to individual minerals, amino acids, and vitamins were found. Flavor of the reconstituted imitation milks was rated as fair to very poor. Four of the imitations contained soy protein, seven contained casein, and two were apparently a mixture. The predominant carbohydrate was glucose, but seven also contained sucrose. Maltose was found in 75% of the samples, dextrin in all, and lactose was found in two.

Stain for direct microscopic count improved.--Reports were received from nine of ten collaborators comparing the periodic acid-bisulfite-toluidine blue and the pH 4 toluidine blue stains with the standard Levowitz-Weber stain. Preliminary examination of the results shows substantial interlaboratory variation in counts. Variation in counts is independent of the staining method used or of who prepared the stained smear. The periodic acid-bisulfite-toluidine blue stain appears to give higher average counts on nonfat dry milk than the other two.

Abnormal heat resistance of bacteria.--Studies show that large populations of bacteria commonly contain a small number ( $1$  in  $10^6$ - $10^8$ ) of cells with abnormal heat resistance. Resistance appears to be physiological rather than genetic since subcultures of heat resistant survivors were not more heat resistant than the original culture. A fresh culture was heated in a suspension of cells previously killed by heating, to determine if the dead cells would protect the few survivors from heat. No protective effect of the dead cells was observed. Project was terminated.

Rapid method for separation of milk proteins developed. The reproducibility of electrophoretic patterns on cellulose acetate was improved by the use of more dilute buffers and higher voltages. Tests conducted with skim milk showed that good separations of the A and B forms of  $\beta$ -lactoglobulin can be



obtained with an electrophoresis running time of only three minutes. This method can replace the present technique for this separation which requires several hours' running time on polyacrylamide gel.

### Protection from Harmful Micro-organisms and Naturally Occurring Toxins

Microbiological condition of milk.--The bacteriological quality of raw milk was frequently found to be poor, based on 545 samples. Samples collected during four seasons showed a significant seasonal effect with highest counts during the rainy season. Quality of pasteurized milk was also poor and there was evidence of extensive post-pasteurization contamination. Quality of pasteurized milk was improved this year over last, probably because of removal of the bulkholder from the system. Unclean equipment and contaminated water supplies undoubtedly contributed to bacterial loads in both raw and pasteurized milk. Large numbers of coliforms and enterocci were found in water, soil, and fecal samples. Based on characterization of 310 coliform and 307 enterococcus isolates the E. coli and S. faecalis groups dominated the coliform and enterococcus populations, respectively.

Inhibiting microbial resistance.--Orange oil was found to have no effect on the heat resistance of two species of bacteria. The project was terminated during the reporting period.

### Protection Against Insects

#### Biology, Ecology, Physiology, and Nutrition

Insect response to metabolites of the khapra beetle.--The incorporation of linoleic acid in the larval food of the khapra beetle causes a marked delay in pupation. Certain fatty acids (C<sub>5</sub>-C<sub>8</sub>) repel khapra beetle females but the insects react differently to capric and undecanoic acids. The beetles were attracted by myristic and pentadecanoic acids at 1.0 and 5.0 milligrams per paper disc. Palmitoleic acid elicited the highest response (+47.2%), whereas stearic, oleic, lineolic, and linolenic acids were ineffective. Nonadecanoic acid was attractive at the 5.0 milligram level. Amides of pelargonic and capric acids repelled khapra beetle larvae and Tribolium castaneum adults, and tridecanoic, pentadecanoic, and stearic acids attracted the beetles.



Behavior and structure clues to pheromone secretion.--Studies of an unusual "calling" behavior of female dermestid beetles have resulted in information on pheromone production. The "calling" usually begins in the morning and continues until early evening with peak activity for most species in the early afternoon. The pheromone is secreted in greater quantity during "calling." Preliminary evidence suggests synthesis activity in the pheromone glands undergoes a daily rhythm. A secretory epithelium underlying the 7th abdominal sternite (last visible segment) is believed to be the source of pheromone synthesis in the four Trogoderma species studied.

#### Biological and Physical Control

Trogoderma sex attractant identification.--Sex attractants from females of Trogoderma glabrum were extracted with solvent. Following solvent evaporation, short-path distillation, column chromatography, and gas-liquid chromatography, five active components were isolated. One attractant has been identified as a 17-carbon alcohol containing a single trans-double bond and a single methyl branch. Two other active components have been tentatively identified as homologous methyl esters of the cis-ester found in T. inclusum. Another compound of much lower molecular weight has been tentatively identified.

Use of pheromone traps.--Field experiments with traps treated with synthetic or natural pheromones of either Trogoderma inclusum or Attagenus megatoma have generally been successful in trapping these species. Other species, too, of stored-product insects have been attracted to these traps. Improved procedures for synthesizing gram quantities of 14-methyl-cis-8-hexadecen-1-ol have been developed. Pheromone work has progressed to the point that Trogoderma traps with attractants are in the hands of Agricultural Quarantine Inspection personnel at ports where the khapra beetle is encountered so that they may be evaluated as regulatory tools.

Antimicrobial agents affect insect life.--Survival and fecundity of Trogoderma variabile and Attagenus megatoma were studied after antimicrobial food additives had been incorporated in their diets. Sodium benzoate, methyl p-hydroxy benzoate, propyl p-hydroxy benzoate, n-heptyl p-hydroxy benzoate, propionic acid, sorbic acid, butylated hydroxy anisole, and butylated hydroxy toluene had adverse effects on either egg hatch or larval development. Citric acid and propyl gallate had no adverse effect. In a more detailed study on the effect of sorbic acid and relative humidity on T. variabile egg viability, it was found that sorbic acid had no effects at low relative humidity but at 60% or higher hatching was adversely affected at 0.5% concentration and no hatch occurred at 1% or above.

## Improved Insecticidal Control

Residual insect control treatments.---The toxicity of bromophos, ronnel, and malathion are influenced by the surface to which the insecticide is applied. The most promising coatings for improvement of malathion residue toxicity to black carpet beetle larvae on concrete were fat base, stabilized; alpha-methylstyrene polymer, resin 55.5%; silver paint; traffic marker paint; and paraffin wax.

Treatment of masonry surfaces with paraffin wax did not extend the residual effectiveness of malathion sprays against flour beetles, but the treatment did extend the effectiveness of Gardona up to 22 weeks. A 10% propionic acid surface treatment extended the malathion effectiveness up to 7 weeks.

## DECIDUOUS FRUITS, BERRIES, AND TREE NUTS

## Quality Maintenance in Storage

## Controlled Atmosphere Storage

Eastern apples.--Research has shown that apple fruit quality can be maintained better under conditions of continuous controlled atmosphere (CA) for up to 9 months than under any other storage conditions tested. Apples from continuous CA storage were firmer, more acid, had lower respiration rates and were more often preferred by taste panelists than were those from air or CA plus air storage. Air-stored fruit were least preferred, softest, lowest in acidity and had the highest respiration rate. Fruit from the various CA plus air storage regimes were of intermediate levels with respect to preference, firmness, acidity, and respiration. These intermediate levels corresponded roughly with the duration of time the apples were in CA. The longer the time in CA the more closely the fruit approached the quality and metabolic state of fruit from continuous CA storage.

Eastern peaches and nectarines.--Four peach varieties (Sunhaven, Redhaven, Loring and Redskin) and one nectarine variety (Late Le Grand) were subjected to a series of storage regimes in which both the atmospheres and temperatures were shifted during storage to repeat 1969 tests (fig. DF-1). Decay was a serious problem, especially after 9 weeks' storage.

Fruit held continuously at 32° F. under CA conditions retained better quality than fruit held continuously in air after 6 and 9 weeks. Fruit quality appeared to be associated with both CA-exposure time and to the warm-up treatment. In general, respiration was lower the longer the exposure to CA. Such fruit usually had less flesh discoloration and flavor ratings tended to be higher for fruit from the longer CA exposures. A warm-up treatment before or during storage appeared to be more effective in maintaining fruit quality the later it was imposed on the fruit.

Varieties responded differently to treatments. Redskin peaches did not retain acceptable quality for 6 or 9 weeks under any storage conditions tested. Late Le Grand nectarines had acceptable quality after 9 weeks' storage only when stored 6 weeks in CA at 32° F. plus 2 days at 65° F. followed by 3 weeks in air at 32° F.

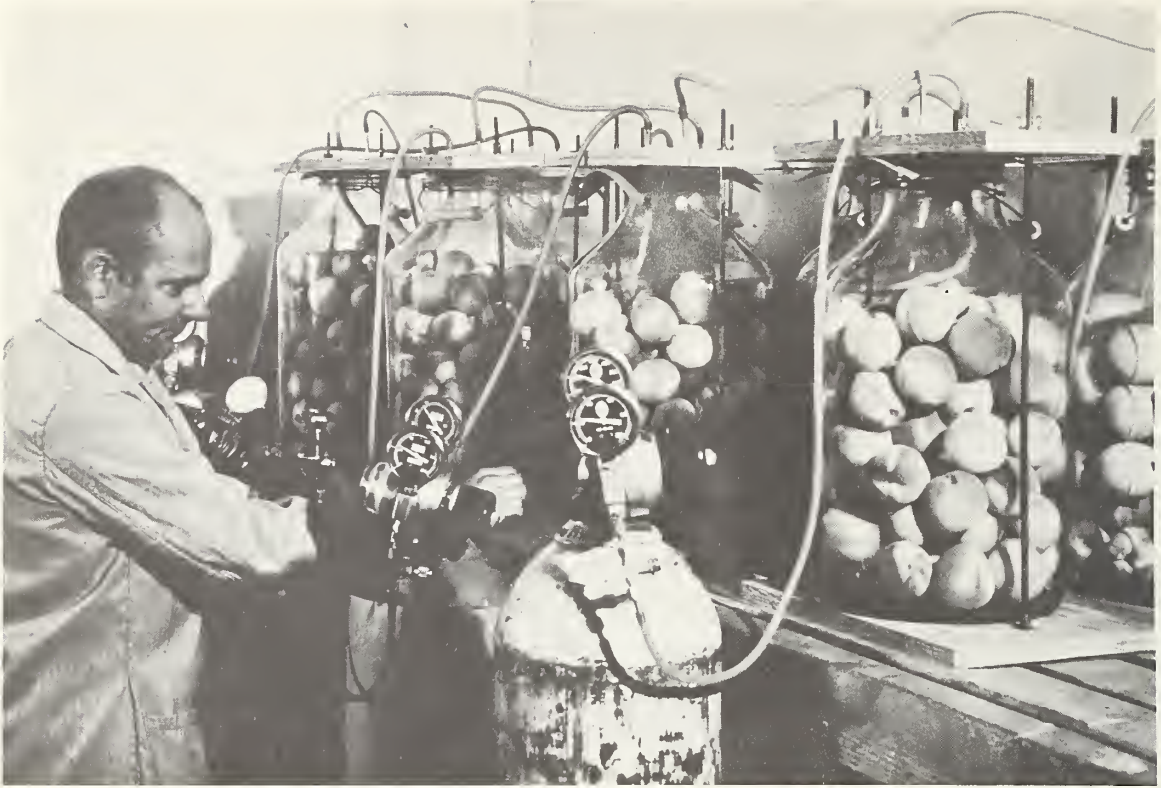


Fig. DF-1.--Controlled atmosphere experiments to extend storage life of peaches at 32° F.

#### Common Storage

Chinese gooseberry (*Actinidia chinensis*).--Fruit softened slowly during storage at 32° F. but the rate of softening increased with storage time. The increase in deformation of fruit under a 1-kilogram load ranged from 0.3 to 0.7 millimeters (mm.) per month when stored at 32° F. and increased an average of 0.3 mm. per week during ripening at 70°. Most fruit were edible after storage for 12 weeks at 32° without further ripening.

Fruit softening during storage was accompanied by a decrease in acidity and an increase in percent soluble solids. The increase in soluble solids occurred primarily at the stem-end of the fruit.

Weight loss averaged 0.3, 1.1, and 4.0% after storage at 32° F. for 4, 8, and 12 weeks, respectively, and ranged from 1.0 to 2.0% per week during holding at 70° F.



## Quality Maintenance During Transit

Truck shipments.--Strawberries averaged 37° F. in open pallets and 38° in polyethylene-covered pallets during shipments by truck from Salinas, California, to Chicago, Illinois. Covered pallets with "Tectrol" atmospheres (2% O<sub>2</sub> + 20% CO<sub>2</sub>) added at origin averaged 16% O<sub>2</sub> and 8% CO<sub>2</sub> on arrival in Chicago. Decay of berries in open pallets averaged 7% on arrival and 16 and 24% after 1 and 2 days at 60° F. Berries in Tectrol treated pallets averaged 3% on arrival and 8 and 21% after 1 and 2 days at 60° F.

Export air shipments.--Berry temperatures which averaged 39° F. initially, averaged 39° in the center and 57° in the top layer of pallets in New York (Kennedy Airport), and 41° in the center and 59° in the top upon arrival in Frankfurt, Germany. All pallets were covered with shrinkable polyethylene film (fig. DF-2). Carbon dioxide in pallets containing dry ice averaged 11% in San Francisco, 23% in New York (Kennedy Airport) and 27% at Frankfurt. Decay averaged 2.8% on the morning following arrival in Frankfurt and 8.5% after holding 24 hours at room temperature. The top layers had about twice as many decayed and overripe fruit as the center layers.



Fig. DF-2.--A pallet of strawberries covered with shrinkable polyethylene film.

Domestic air shipments.--Berry temperatures averaged 43° F. in the center and 53° in the top layers of uncovered pallets after shipment by air in a fiberglass "igloo" container from San Francisco to New York. Berry temperatures averaged 39° F. in the center and 59° in the top layers of pallets covered with fiberboard sleeves, which accompanied the "igloo" container. Decay averaged 0.5% on arrival and 3% and 8% after 1 and 2 days at 60° in berries shipped in fiberboard sleeves. Berries shipped in the "igloo" container averaged 1%, 2% and 11% decay after the same holding periods.

### Postharvest Physiology

Pears.--In research conducted under a cooperative agreement with the Mid-Columbia Experiment Station of the Oregon Agricultural Station, Anjou pears were picked at four stages of development (12, 15, 18 and 21 weeks of their total growth period) and subjected to varying concentrations (0, 0.05, 0.1, 0.2, 0.5, 1.0 and 2.0 ppm) of ethylene. Ethylene caused an immediate sharp increase in respiration of young fruit. The height of this temporary climacteric-like rise was in proportion to the concentration applied, and was reduced as the fruit approached maturity.

With an increase in fruit maturity, the minimum concentration of ethylene required to initiate softening and climacteric rise was decreased. Sensitivity of the fruit to applied ethylene increased with advancing maturity. In fruit less than 86% mature (18 weeks from full bloom) softening occurred ahead of the onset of the climacteric rise in respiration. Softening required a lower threshold concentration of ethylene than did the climacteric. An increase in ethylene production occurred prior to initiation of softening but a greater production was associated with the climacteric.

Toxicology.--Diphenylamine (DPA) toxicology studies were conducted under contract by the Albany Medical College in which DPA was fed in a diet to groups of mice at three levels (0.005, 0.01, and 0.025%) plus a 0.0% level control for periods up to 92 weeks. Between 100 and 200 males and an equal number of females were tested at each level. There were no significant effects of the different diets on the growth, survival, spontaneous diseases, iron content of spleen or liver, incidence of histopathological changes, anemia and rate or incidence of tumor formation. No carcinogenic potential was observed. Effects observed included increased levels of Heinz bodies and destruction of some erythrocytes with increased levels of DPA in the diet. The Heinz body levels fell rapidly on cessation of DPA feeding. Assuming a human intake of 5 mg of DPA daily a safety factor of at least 400 is indicated for all observations except for Heinz bodies where a safety factor of 100 would exist for their appearance.

## Postharvest Disease Control

Emphasis in 1970-71 was in determining the effectiveness of combinations of fungicides, fungicides applied in hot waxes, and heated fungicide suspensions in controlling serious decays.

Apples--Blue and gray mold rots.--Both benomyl and thiabendazole (TBZ) used as 10-15 second dip treatments at 500 ppm controlled decay due to blue mold (Penicillium expansum) (figs. DF-3 and DF-4) and gray mold (Botrytis cinerea) at puncture wounds in inoculated Eastern Red Delicious apples during storage. The chemicals were less effective in controlling decay at bruises unless suspensions were heated in a range of 84°-113° F. and used as a 2-minute dip. The fungicides were less effective in controlling decay at punctures when treatment was delayed 24 hours after inoculation. TBZ added to water contaminated with blue mold spores, as in a dump tank, controlled decay at skin punctures but not at bruises during subsequent storage.

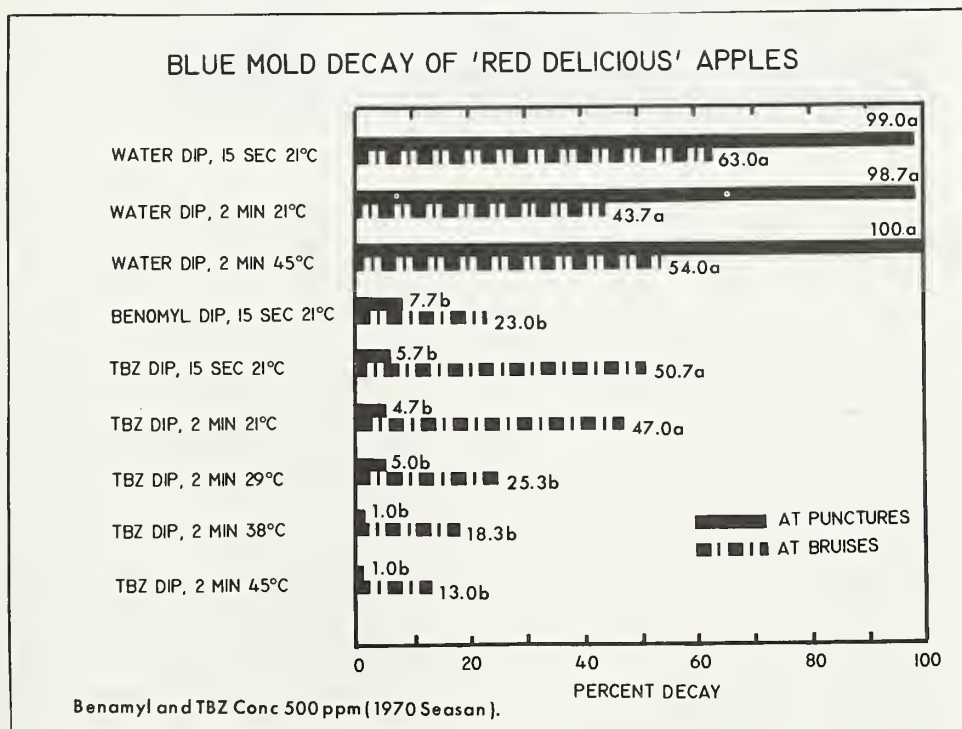


Fig. DF-3.--Effect of unheated and heated water, benomyl, and thiabendazole (TBZ) as postharvest dip treatments on decay of apples inoculated with Penicillium expansum spores at puncture and bruise wounds, and stored for 2 months at 32° F. plus 6 days at 70°.



Fig. DF-4.--Blue mold of Red Delicious apples controlled during storage by brief postharvest thiabendazole dip.

Neither benomyl nor TBZ controlled *Alternaria* rot on apples which often developed at punctures when blue and gray mold were controlled.

At Wenatchee, wounded apples inoculated with *Penicillium expansum* and coated with plain wax developed 99% decay, whereas, fruit coated with wax containing 1000 ppm benlate or TBZ developed only 10% blue mold decay.

Wounded Western apples were dipped in spore suspensions of *P. expansum* 10, 30, 60 and 120 minutes after addition of fungicides at the recommended concentrations. Spores treated with sodium orthophenylphenate (SOPP) produced 92, 90, 91 and 88% infection. The percentage infection with chlorine was 34, 22, 14 and 11, whereas, that with TBZ was 0, 2.5, 0.4, and 0.8. The untreated check developed 98% infection.

Bitter pit.--Postharvest hot-air treatments made at Beltsville did not prevent development of bitter pit. Hot-water treatments for 4 minutes at 125° F. reduced external bitter pit slightly, but longer treatments caused



severe skin injury. Untreated apples held 30 days at 32° F. plus 30 days at 50° showed 87% external bitter pit compared to 82% for fruit treated in hot water at 125° for 4 minutes. When examined internally, untreated apples showed 90% bitter pit compared to from 80% down to 38% for fruit treated for 2 to 10 minutes at 125°.

Scald.--Two formulations of ethoxyquin were applied to Red Delicious apples at 50°, 70° and 90° F. Both formulations controlled scald at 90°. The commercial formulation produced commercially acceptable control of scald at 70°, but the experimental formulation did not. The experimental formulation worked better than the commercial one at 50°, but neither produced commercially acceptable control at this temperature.

Combining TBZ with both formulations of ethoxyquin at 90° F. neither reduced scald control nor caused injury. A combination of TBZ and emulsifiable diphenylamine (DPA) produced excellent scald control and no chemical injury.

Dipping apples in water at 125°, 127° and 129° F. for 1, 2, or 3 minutes controlled scald on Red Delicious but heat injury increased with temperature, and with the length of exposure. In this series of tests, only 125° for one minute controlled scald without injuring the fruit.

Stone fruits--Brown rot and rhizopus rot.--Peaches inoculated with Monilinia fructicola or Rhizopus stolonifer were treated with heated (130° F.) or unheated (75° F.) dips or sprays for 10, 20 or 30 seconds with 225, 450 or 900 ppm 2,6-dichloro-4-nitroaniline (DCNA) suspended in a wax emulsion. The mean diameter of the decay lesions were significantly smaller on fruit treated with the DCNA-wax emulsion. Similar wax-benomyl [methyl-1(butyl-carbamoyl)-2-benzimidazole carbamate] treatments at 10, 33 or 100 ppm were also more effective than benomyl treatments alone. Heated DCNA treatments, whether as dips or sprays, and with or without wax, were more effective than unheated treatments. Heat improved the effectiveness of all benomyl dips or of 10-second wax spray treatments. Means of percent decay of uninoculated peaches and nectarines due to Monilinia and Rhizopus infections were significantly less when treated with a 10-second heated wax spray containing 450 ppm DCNA and 100 ppm benomyl than with a 3-second unheated spray.

Treatment of peaches inoculated with either Monilinia fructicola or Rhizopus stolonifer spores with high humidity air (85-95% RH) for 24 hours at 105° F. controlled decay as well as dips for 2½ minutes in 125° F. water (fig. DF-5) or for 5 minutes in 115° water. When the relative humidity of the air during treatment was low (37%), decay control was less effective. The high humidity air treatment did not affect appearance, ripening or flavor of the fruit but low humidity 105° air caused shriveling of the fruit.

Fig. DF-5.--Effect of 2½-minute non-heated and heated water and chemical dip treatments on postharvest decay of peaches after 6 days at 65° F.

Postharvest Treatment	Percent decay using--	
	70° F water	125° F water
Decay caused by <u>Monilinia fructicola</u>		
Water dip (control)	85	1
DCNA	76	9
Benomyl	33	4
Decay caused by <u>Rhizopus stolonifer</u>		
Water dip (control)	85	12
DCNA	71	12
Benomyl	83	15

Residue analyses.--At Fresno, peaches, nectarines, and plums treated with cold or hot applications of botran in wax suspension were analyzed for residual fungicide on the fruit. Hot wax-fungicide applications caused more residue to remain on the fruit than cold applications. About 10 ppm fungicide residue is necessary for effective brown rot control.

Peaches treated in commercial packing sheds showed a wide variation in botran residues on the fruit. Concentrations ranged from about 1 ppm to 20 ppm. Brown rot control was correlated with chemical residue remaining on the fruit.

Chemical residues on peaches, nectarines, and plums differed greatly when the fruit was sprayed with a wax-fungicide mixture. Spraying a mixture containing 2.2 pounds botran per 100 gallons spray on peaches resulted in botran residues of 13 ppm; but on nectarines and plums, residues of only 2 to 3 ppm were obtained. Consequently, treating these fruit in a packinghouse requires a change in procedure or a change in equipment to control decay effectively. Preliminary tests indicate that increasing the concentration of fungicide in the spray, lengthening the exposure to the spray, or heating the wax-fungicide mixture are effective ways to increase fungicide residues and effectiveness of decay control.

Pre- and postharvest spray application.--Benomyl applied as bloom and/or postharvest sprays reduced postharvest decay but additional postharvest treatments with botran or hot water were necessary to reduce decay levels to commercially acceptable levels.

Sweet cherries.--Brown rot (Monilinia fructicola) of sweet cherries was effectively controlled by postharvest dips in either 100 or 500 ppm suspensions of benomyl at 70° F. Treating fruit in 145° water for 2½ minutes controlled decay as well as a benomyl dip, but treating in 115° water for 5 minutes or 125° water for 2½ minutes gave significantly better decay control. When 100 ppm benomyl was added to the 115° water treatment (2½ minutes), decay control was as good as in 115° water for 5 minutes or in 125° water for 2½ minutes. Cherries exposed to high humidity air (95% RH) at 115° or 125° for 15 or 30 minutes or in 105° air (85-95% RH) for 24 hours developed about the same percent decay as those given the best hot water treatments. Injury occurred on cherries exposed to 125° air for 30 minutes and on those treated with benomyl at 125°.

Strawberries--Preharvest fungicide applications.--In exploratory cooperative research with the Fruit and Nut Crops Branch, Plant Science Research Division, it was found that preharvest sprays with benomyl (3 lbs per acre) increased the yield of healthy strawberries at harvest. The same spray treatments did not have a consistent effect on preventing decay of berries during postharvest holding. About the same amount of decay developed on berries held consistently at 65° F. as on those held at 32° before transfer to a 65° holding temperature. Postharvest applications of benomyl did not prevent decay development (primarily gray mold).

DHA-S dips.--Strawberries dipped in 1/2% sodium dehydroacetic acid (DHA-S) showed injury at all hypobaric (low pressure) pressures but no mold developed. Berries treated with hot-moist air were not injured by hypobaric storage but showed some mold during and after storage.

Blueberries--Postharvest dips.--In exploratory research, neither benomyl, botran nor thiabendazole (TBZ) at 500 ppm used as postharvest dips effectively controlled decay caused by Botrytis, Penicillium, and Rhizopus on inoculum blueberries. A 2-minute dip in hot water at 113° or 125° F. was more effective than any of the unheated fungicides in controlling decay. The best control of postharvest decay was obtained with 500 ppm suspension of benomyl heated to 125° as a dip treatment.

Decay in mechanically harvested blueberries.--In a preliminary quality evaluation of mechanically harvested blueberries for fresh market, an examination made the same day the berries were harvested showed 9.4% of the berries sufficiently defective to warrant discarding. The principal defects were anthracnose (3.5%), insect damage (3.0%), and over-maturity (1.4%). An additional 6.8% was wasted by anthracnose (4.3%) and excessive softness (2.5%) after the blueberries were held for 3 days at 60° F.



Blueberries.--New Jersey blueberries were surveyed for decay in several Greater New York retail outlets during the summer of 1970. Of more than 33,000 berries examined, 7.4% were decayed. Anthracnose (5.4%) and gray mold rot (1.7%) were the leading decays.

Pecans.--In cooperative research with the University of Georgia, fungi were found to be present at a high level in young pecan fruits, husks and shells throughout the growing season. The fungus level in the partition was found to be low early in the season but increased as the fruits matured. No fungi were found in embryos but as the seeds matured, the fungus level increased, approaching 100% infected seeds at maturity. Considering data for all samples together, Phoma (37.1%) was the most common fungus in young fruits and husks followed by Alternaria (24.8%), Pestalotia (22%), Epicoccium (14.3%), and Fusarium (12.2%). In the shell and partition Pestalotia (33.7%) was most common followed by Fusarium (21.1%), Cladosporium (16.5%), Phoma (14.8%), Penicillium (8%), Alternaria (4%), and Aspergillus flavus (3.4%). Cladosporium (13.3%) was the most common fungus in seeds, followed by Fusarium (11.3%), Penicillium (9.3%), Pestalotia (8%), and Phoma and Aspergillus flavus (6.6% each).

Market losses.--Health foods - Aspergillus flavus was present in all 12 samples of sunflower kernels obtained from 6 Chicago health food stores.

Pears.--A new storage decay of Bartlett pears is under investigation in the Chicago market. The rot lesions, which are slightly sunken, firm and dark brown increase in size at cold storage temperatures. The fungus has tentatively been identified as the genus Coniothecium.

The extent and nature of loss in several important fruits was investigated in retail outlets located in low, middle, and high income areas of Greater New York. Losses in retail stores averaged 1.2, 4.0 and 2.7% for Bartlett, Bosc and Anjou pears, respectively. Mechanical damage was the leading cause of loss in all varieties. Decay caused less than 25% of all losses. Consumer samples held at 70° F. until ripe (1-3 days) had 5.8, 4.9 and 2.2% waste in Bartlett, Bosc, and Anjou pears, respectively. The main cause of loss was internal breakdown in Bartlett and Bosc and mechanical damage in Anjou. Decay losses were less than 1.0% in the 3 varieties.

Cherries.--In a survey of losses in the Chicago market cherry losses in the retail packout were 10.6% from parasitic diseases and 2.9% physiological disorders. Retail shelf losses were 1.3% from parasitic diseases and 0.8% physiological disorders. Consumer losses for cherries were 10.5% parasitic diseases, 5.3% physiological, and 2.4% from physical damage.



Scald appeared on the newly introduced early California cherry variety in the Chicago market. The fruit exhibited skin and flesh browning without visible evidence of bruising. The disorder was traced to high winds occurring before harvest which caused rub bruising. The disease was reproduced on this variety in the laboratory by simulated roller bruising. The disease developed irrespective of the temperature after bruising had occurred.

Plums.--Losses for Italian prune plums in the retail packout were 0.2% from parasitic diseases and 0.3% from physical damage. Consumer losses were 1.1% from parasitic diseases and 0.1% from physical damage.

Grapes.--Retail losses were 11.0% for Thompson Seedless and 5.3% for Emperor grapes. Internal browning (4.3%) and shattering (6.5%) caused most of the loss in Thompson Seedless grapes. Sulfur dioxide injury (3.1%) caused most of the loss in Emperor grapes.

Causal organism identified.--Stem-end rot of imported Chinese gooseberries was determined to be due to the fungus Phomopsis sp., by plant pathologists at the Chicago Market Pathology Laboratory. The optimum temperatures for spore germination were determined to be in the range 60-86° F.; for germ tube elongation 77° F., and for colony growth 68° F. On infected fruit, the optimum temperature for decay was 86°. Decay was present in lesser amounts after 7 days at 68°, or 77°. At 60°, decay was visible after 9 days, at 50° after 11 days, and at 41° after 20 days. The spores of the causal fungus germinated better in a sucrose-sodium citrate medium than in distilled water.

## Fundamental Research

Related fundamental research was directed towards obtaining a basic understanding of the physiology of microorganisms which cause postharvest diseases.

CA effect on bacteria.--A study was made of the effect of controlled atmosphere (CA) on the growth of bacteria. The growth of 6 strains each of Erwinia carotovora, E. atroseptica, and Pseudomonas fluorescens in an asparagine-yeast extract medium at 20° C. in atmospheres of 3% carbon dioxide and 21, 3, 1, 1/2, 1/4 and 0% oxygen decreased linearly with decreasing oxygen concentrations. Mean percentages of growth of E. carotovora, E. atroseptica, and P. fluorescens after 24 hours in 3% oxygen plus 3% carbon dioxide compared to growth in air were 60, 54, and 56%, respectively. Growth in 0% oxygen plus 3% carbon dioxide ranged from 5 to 7% of the growth in air.

In oxygen atmospheres containing no carbon dioxide only 4 of the 6 strains of E. carotovora were capable of growth after lag periods of 45 to 93 hours at 20° C. Growth of P. fluorescens was unaffected by the absence of carbon dioxide, and that of E. atroseptica required carbon dioxide.

Enzymes related to bacterial pathogenicity.--The manipulation of enzyme production and the concomitant effects on virulence was found to directly implicate enzymes in the production of soft rot. In Erwinia carotovora, the enzyme profiles of 7 prototrophic independently obtained avirulent mutants (AV) were compared with 4 partially revertant strains (PRV), the fully virulent revertant (RV) and wild-type (WT) strains. In supplemented growth media containing the inducers polygalacturonic acid, carboxymethylcellulose, purified soybean lecithin, or lima bean extract, all AV strains produced low levels of cellulase, variable amounts of polygalacturonase and pectate lyase and no phosphatidase (fig. DF-6). When compared to AV, those PRV strains

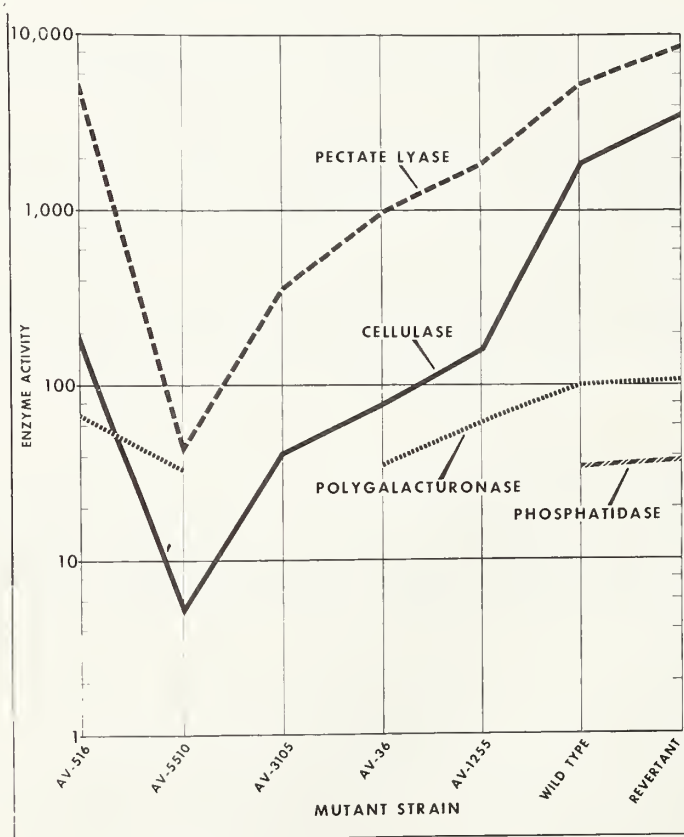


Fig. DF-6.--Relative enzyme activities of avirulent (AV) wild-type and revertant strains of Erwinia carotovora.

producing the most cellulase and polygalacturonase were intermediate in their virulence. Like the AV strains, all PRV strains tested failed to produce phosphatidase. The virulent WT and RV strains obtained from the AV by comparison had consistently higher unit values of polygalacturonase, pectate lyase, cellulase and phosphatidase.

New assay medium developed.--A new enzyme-toxin assay medium was developed. The substrate medium, which is autoclavable, permits a rapid quantitative approximation of phosphatidase activity in either concentrated lyophilized cell-free extracts of in situ around a single growing colony of Erwinia carotovora. The homogenized lecithin source and the nature and pH of the suspending basal medium were factors influencing the successful application of the medium. As a group, the phosphatidase enzymes have been associated with toxic properties of a number of animal and plant pathogens. They are constituents of snake and insect venom and toxins from human pathogenic bacteria such as Staphylococcus, Bacillus and Clostridium species.

Growth media compared.--Three strains of Geotrichum candidum were compared for growth in a minimal basal salt medium with added natural or undefined supplements. The order for growth for natural supplements was as follows: yeast extract > casamino acids > vitamin-free casamino acids. Cell-free extracts of both virulent and avirulent strains of Erwinia carotovora did not increase growth of any G. candidum strains tested. Among defined supplements tested, only glycine, aspartic acid, and glutamic acid stimulated growth. Thirty-three other amino acids, vitamin growth factors, purines, and pyrimidine bases tested were ineffective.

Selective medium developed.--A medium containing 1000 ppm pentachloro-nitrobenzene (PCNB), 20 grams strained canned peaches, 100 ppm Neomycin and 500 ppm Streptomycin was developed for the selective growth of Monilinia fructicola (Wint.) Honey and M. laxa (Aderh. & Ruhl.) Honey. While allowing rapid growth of Monilinia species, the medium represses Mucoracious fungi and restricts other contaminating fungi and bacteria to discrete colonies. Counts of viable spores made with a hemocytometer corresponded to plate counts on the medium over a dilution range of from 1:10 to 1:10,000 (1 equals 46,000 spores/ml.). Counts of colonies on the medium served to measure the inoculum density when spores made up a very small portion of the total population. For example, a 6-month old peach mummy had 25,000 viable spores in March 1971 when the total Monilinia spore population was estimated with the hemocytometer to be  $85 \times 10^6$ . Washing freshly harvested peach, nectarine, and plum fruits showed that the inoculum density ranged from 300 to 22,000 viable spores per fruit, which caused 1 to 50% decay after a simulated storage and marketing period of 24 hours at 2° C. and 4 days at 25° C.

Fungicide resistance.--A study was made of cross resistance of Penicillium expansum to new fungicides. In vitro mutants of P. expansum resistant to either sodium orthophenylphenate (SOPP), sodium dehydroacetate (DHA-S), acriflavine (ACR) or parafluorophenylalanine (PFPA) were tested against different levels of botran, tutane, benomyl and thiabendazole (TBZ). At all concentrations tested, none of the mutants or wild-type P. expansum were inhibited by tutane. All SOPP resistant mutants were somewhat resistant to botran. All other mutants were resistant to their respective fungicide from which they were obtained but none were resistant to benomyl or TBZ at any of the concentrations tested.

Differential response of fungi to fungicides.--The differential response of genera and strains of fungi to fungicides was studied. The differential response to fungicides of genera and strains within genera demonstrated the importance of the proper (1) material, (2) concentration of fungicide, and (3) combination of chemicals used for disease control.

In Penicillium expansum, P. digitatum, and P. italicum the order for fungicidal effectiveness (based on minimal levels needed for inhibition after 72 hours) was as follows: TBZ was greater than benomyl; benomyl was greater than SOPP; SOPP was greater than botran; botran was greater than DHA-S; DHA-S was greater than tutane.

With TBZ, benomyl and DHA-S, the 3 species of Penicillium did not show variations in their reactions. However, in 10 and 30 ppm SOPP, P. digitatum and P. italicum were more resistant than P. expansum. In botran, at all concentrations tested to 200 ppm, P. italicum was resistant while P. digitatum and P. expansum were sensitive.

In Geotrichum candidum all isolates from peach, melon, and citrus were resistant to tutane, TBZ, benomyl and botran at all levels tested. However, SOPP and DHA-S were inhibitory to all isolates. SOPP was more effective than DHA-S at 30 and 50 ppm. Within the isolates, the one from citrus (but not the melon or peach) was the most resistant to SOPP. In 200 ppm DHA-S, the peach and melon Geotrichum were slightly more resistant than the citrus isolates.

#### Quality Evaluation

Electrical properties of apples.--The electrical properties of apple tissue were characterized for the 5- to 900-mHz range. The results indicate that reproducible measurements of the dielectric constant can be made with the sample holders developed in this project. The dielectric constant showed a small but significant decrease with maturation for Delicious,



Winesap, and McIntosh apples, ranging from 70 to 55. The greatest change occurred in the 4-mHz range with the dispersion of dielectric constant being in the 5- to 150-mHz range. A measurement of the dielectric constant should be of value in indicating stage of maturation of apples with the most useful frequency range being less than 100 mHz.

Instrumentation for light measurements improved.--A high-energy spectrophotometer has been completed and tested. The basic component is a specially designed grating monochromator with automated wavelength scanning mechanism. Photomultipliers and photodiodes are used as detectors in combination with solid state amplifiers. Data can be recorded on an X-Y recorder or digitized and recorded on punched paper tape. Sample compartment assemblies provide for convenient measurement of reflectance and transmittance of a wide range of agricultural products. The monochromator provides 10mw of power at 700nm with a spectral bandpass of 9nm. The stray light is 0.1% but can be reduced to 0.0001% with supplementary filter monochromator. The instrument is capable of measuring samples having an optical density as high as 10.

Fruit soluble solids and acidity.--In cooperative research with the Washington Agricultural Experiment Station, little differences were found in fruit soluble solids and acidity between treatment (check, calcium, triiodobenzoic acid (TIBA) and TIBA + calcium) at harvest or during the storage period. Firmness was the same at harvest but in May, TIBA-treated fruit was one pound softer than the check or check plus calcium fruit. Fruit treated with TIBA plus calcium was 0.7 pound firmer than fruit treated with TIBA alone.

Alar and fruit firmness.--In an orchard with high and low vigor trees, fruit treated with Alar was about one pound firmer at harvest from both stages of maturity (145 and 155 days from bloom). After 8 months' in storage, low vigor Alar fruit from the first picking was 0.8 pound firmer than check fruit but only 0.4 pound difference occurred in fruit from the high vigor trees. Firmness of fruit from the second harvest was about the same between treated and check fruit after 8 months' storage. Although soluble solids are not affected by the Alar treatment, fruit from low vigor trees is consistently a little higher than that from high vigor trees. The same relationship holds for titratable acidity.

Fruit from Alar sprayed trees in two orchards average one pound firmer at harvest than check fruit. The difference was less than one-half pound after 8 months' storage. Alar did not affect soluble solids but increased titratable acidity.

Automatic apple sorter.--A machine is being developed to use the light transmittance technique for sorting apples to detect water core and sort into 3 maturity classes. Previous studies have shown that apple quality can be determined objectively by measuring the difference in optical density at two wavelengths. The fruit was reoriented so that the light traversed from the calyx to stem end. Systematic orientation of apples may not be feasible economically or physically for automatic sorting in a commercial packing-house. A study of the need for orientation indicated that chlorophyll content and water core discrimination can be made at random orientation if a large area detector is used close to the sample.

Taste panel tests conducted this year with Eastern and Western Red Delicious apples sorted by  $\Delta OD$  (690-730 nm) measured on the high density spectrophotometer have shown that systematic orientation of apples was not necessary for quality sorting.

Water core detection instrument.--Research has resulted in the development of an inexpensive water core detector by a Seattle firm. In preliminary tests, the detector checked out with the Difference Meter and visual examinations. A demonstration given to a few industry personnel has resulted in orders for several instruments for use in Washington warehouses.

Red sports of Red Delicious apples.--There appears to be no difference among the sports in time from bloom to maturation. The fruit from spur-type trees does not generally rate quite as high as that from some of the standard growth type trees in dessert quality. All sports tested to date seem to keep equally well and are acceptable in dessert quality. The intensity and shade of red pigmentation varies as well as whether the color is uniformly distributed or blush type as opposed to a striped apple.

Chlorophyll change in fruit.--Evaluation of reflectance readings on Red Delicious using the Difference Meter indicated that it might be possible to, follow chlorophyll change in fruit as it develops on the tree. A portable color ratiometer using wavelengths of 675 and 730 nm was used to measure the exposed and shade sides of the fruit and in the calyx end of the apples. The calyx area proved to be too irregular to give constant readings. The exposed side of the apple is more subject to extremes in exposure to the sun. Prior to observable sunburn, there was a loss of chlorophyll in that area of the fruit. Generally, the side of the fruit in highest sunlight had a meter reading indicating greatest chlorophyll content.

As red pigmentation started to develop in the test fruit, readings on the meter indicated no further decline in chlorophyll content or even a possible increase. Samples read in the laboratory in the Difference Meter with transmitted light and then with reflected light, indicated that the intense red pigmentation was also absorbing some light of the chlorophyll sensing wavelength.

Blueberry anthocyanin-soluble solids-acidity relationships.--The relationship of anthocyanin content as reflected by LTDM values to soluble solids and acidity of blueberries differed among varieties. Within a variety the relationships were highly consistent regardless of field location or date of harvest. Fruit sorted by LTDM into low, medium and high anthocyanin categories was consistently low, medium and high in both pH and soluble solids. Total acidity at the beginning of harvest was highest in fruits low in anthocyanin. However, total acidity decreased in all anthocyanin categories during the harvest season. During the past three seasons, the variety Wolcott has shown a very high consistency for differences in acidity and soluble solids when sorted into low, medium and high anthocyanin categories.

Blueberry separation by vibration.--A highly significant correlation between fruit firmness and separation by vibration has been established. Multiple regression coefficients account for 80% of the variation and indicate firmness is the primary factor with LTDM value (anthocyanin or ripeness) a secondary factor. These data demonstrate that fruit softened by bruising, and therefore very susceptible to decay organisms, might be reasonably well sorted out by vibration.

Mechanical harvested blueberries.--Results confirm that mechanical harvesters reduce fruit firmness from 20 to 50%. Reduction of firmness is highly correlated with increases in decay during simulated marketing conditions (2 days at 40° F. plus 5 days at 70° F.). Three-minute dips in 120°-125° F. water significantly reduced decay and the addition of thiabendazole (TBZ), maneb and benomyl increased the efficiency of dip treatments.

Sonic vibration techniques.--A new nondestructive random vibration technique for evaluating the firmness of peaches is being investigated. This technique involves vibrating the whole intact peach and measuring the transmission of high frequency vibrations (above 1,000 cycles per second) through the fruit. The ability of peaches to transmit high frequency vibrations decreased as the fruit softened. Results of the random vibration measurements correlated significantly with other firmness tests, such as the pressure test ( $r=0.84$ ). Tests are being conducted to relate this nondestructive test to sensory judgments of firmness. This random vibration test appears to offer a relatively simple nondestructive means for evaluating peach firmness.



## Protection Against Insects.

## Biology, Ecology, Physiology, and Nutrition

Effect of diet on biology, ecology and behavior of *Oryzaephilus* spp.--In single and multiple rearings of *Oryzaephilus surinamensis* and *O. mercator* at 30° C., 50 percent relative humidity, without light, *O. surinamensis* completed development faster than *O. mercator* on oats, raisins and prunes. The reverse was true on almonds. Preoviposition periods were about the same for both species on oats, but shorter for *O. mercator* on almonds, raisins and prunes. *O. surinamensis* laid more eggs on raisins and prunes than did *O. mercator*, but fewer than *O. mercator* on oats and almonds. *O. surinamensis* completed its life cycle faster than *O. mercator* on 8 combinations of oats and yeast.

Ecology of mites on dried fruits and herbs.--Twenty-seven species of fungi commonly occurring in stored food products were evaluated as food for mites under field conditions. Each fungus species studied was suitable food for mites, particularly for *Tyrophagus putrescentiae* (Schr.) and *Acarus farris* (Oud.).

An evaluation of medicinal herbs as food for 5 species of mites was also made. The mites developed more satisfactorily on herbs that are rich in volatile oils, vitamins, and fats. Observations were also made on the influence of active substances of medicinal herbs on mites. Volatile plant oils, alkaloids, and glycosides produced a wide range of effects on mite development.

In other tests, *T. putrescentiae* mites developed most rapidly on rye germ standard food, but less rapidly on almonds and apricots. Raisins and plums were the least desirable foods.

Methyl bromide affects mite's embryonic development.--Eggs of *Acarus siro* fumigated with methyl bromide showed changes in their internal structure. Yolk spheres and blastomers disintegrated. The most distinct changes were at the beginning and end of embryonic development.

Navel orangeworm ecology.--Navel orangeworm field populations were studied by sampling various almond varieties to determine the stages of the life cycle present and the percentages of infestation of almonds throughout the year. Light traps and pheromone traps showed peak adult populations in May, late August to early September, and early October.



## Biological and Physical Control

Bacillus thuringiensis for almond insect control.--A commercial preparation of Bacillus thuringiensis containing spores and crystals was applied to Nonpareil almond trees with 50 percent hull split. The insecticide was applied at 500 ppm; 5 gallons of the suspension was applied to each tree. In these tests the spray apparently was applied too late after the onset of hull split. Earlier treatment will be used in further studies.

Reduction of a source of infestation.--When almonds left on trees after harvest were partially cleaned from an old orchard during the winter, infestation in the cleaned area was lower than in the noncleaned area. This orchard was more thoroughly cleaned in the winter of 1970-71 (20 acres by hand and 20 acres by machine). A young orchard was completely cleaned. Reject losses before and after these tests and cleaning costs will be evaluated to judge the efficiency of orchard sanitation.

## Improved Insecticidal Control

Less residue on raisins from emulsion than from solution.--Raisins dried on paper trays treated with malathion solution picked up more malathion than did those dried on trays treated with malathion emulsion. Raisins dried on malathion-treated trays were protected from insects 9-12 months in storage.

Protectants for stored raisins and walnuts.--Pirimiphos-methyl on raisins and walnuts has shown promising results in 1-day small-jar tests. TD 5032 produced high mortality of red flour beetles, merchant grain beetles, and Indian meal moths. Imidan on walnuts produced no mortality of these insects.

Malathion protects stored almonds.--Shelled almonds sprayed with premium grade malathion as an emulsion and stored in 100-pound burlap bags remained free of insect damage and remained relatively insect free for 1 year in storage.

A use tolerance and a label have been obtained for the use of Cythion (premium grade malathion emulsifiable liquid) as a spray for inshell almonds as they enter storage.

A warehouse test indicated that a malathion-treated paper barrier (bin cover) prevents navel orangeworms from entering stored almonds. However, the test did not show conclusively whether the Indian meal moths would be excluded by the barrier because not enough moths of this species were present.

Control of navel orangeworm.--Eight insecticides were tested against navel orangeworm eggs and full grown larvae. Field application of seven insecticides to navel orangeworm infested sticktight nuts resulted in no insect mortality or phytotoxicity. New foaming agents were compatible with insecticides; however, foams were of short duration.

#### Insect-Resistant Packaging

Protective bags and shipping cases for raisins.--Raisins in bags made of cellophane, polyethylene, polypropylene, EVA, and PVC were infested more when packed in thin than thick films. Cellophane films were first to become infested, followed by cellophane/polyethylene (Poly-Cel) combinations; polyethylene-polypropylene films were most resistant.

Poly-Cel bags with 5:50 pyrethrins-piperonyl butoxide as components of the adhesive layer between the two plies were not infested after 6 months' exposure. Raisin shipping cases with layers of malathion-treated paper on top and bottom were not infested after 4 months' exposure.

## GRAIN, INCLUDING RICE

## Maintenance of Quality

Corn and sorghum storage.--Corn and sorghum were adjusted to 18, 20, and 22% moisture content (MC), treated with 0.5 and 1.0% of six different mold inhibiting chemicals and stored at 25°C. Freshly harvested wheat at 24% MC, treated with 0.5% propionic acid did not mold when stored at 25°C. Similar results were obtained with wheat at 18 and 20% MC treated with 0.3% propionic acid. Moisture contents remained near their original levels for 4 months after which they declined. Acetic acid and sodium propionate were approximately half as effective as propionic acid and calcium propionate was less effective. Sorbic acid and potassium sorbate showed little effect on mold growth. Grain which already had some degree of mold invasion required higher concentrations of mold inhibitors for mold control than sound grain.

No mold growth occurred in a bin of 20% moisture corn when cooled rapidly to 35-40°F. In bins where cooling was delayed one or two days, high populations of Aspergillus flavus and A. niger developed. After cooling to 35-40°F, grain quality remained stable during 3 months of storage.

Invasion by storage fungi at 80% and 85% RH was faster in non-blighted corn with normal cytoplasm than in blighted corn of the same variety having T-male sterile cytoplasm. Ability of the organism to overwinter at Manhattan, Kansas under different conditions was determined.

Rice storage.--In rough rice stored at 25°C for 4 weeks, species of the Aspergillus glaucus group rapidly became the dominant fungi in the variety Belle Patna. At 85% RH, these species invaded 16% of the seed. By increasing the RH to 90%, the number of kernels invaded increased by about 5 times. At 20°C, rice of the same lot stored concurrently was not invaded at 85% RH; however, at 90% RH about 25% of the kernels were invaded. Species of the A. flavus group were the dominant storage fungi during the first 4 weeks of an 8-week storage experiment at 4 temperature and 2 humidity levels. They then declined rapidly in prevalence at 3, 5 and 15°C. At 90% RH, A. glaucus and A. candidus became dominant, while Penicillium spp. became dominant at 5°C.

Dawn rough rice at 19.2% MC was treated with "Grain Shield," a commercial mold inhibitor and stored without aeration. The rice heated in 14 days and was sample grade after 15 days. No storage molds were isolated from this rice but so-called field molds were recovered from

about 92% of the kernels.

Irradiation of wheat.--Irradiation of hard red winter wheat with gamma rays at levels of 20-30 and 40-50 krad for insect control had no apparent effect on milling qualities or baking and physical dough testing properties. Falling number values and amylograph results indicated a steady decrease in alpha-amylase during the year of storage. After storage for one-half month, germination was 83, 72 and 43%, respectively, for wheat irradiated at 0, 20-30 and 40-50 krad. Fat acidity values and fat content remained constant for irradiated samples for the entire 12 months while control samples indicated an increase in fat acidity after 6 months.

#### Determination of Quality

Grain sampling.--The effect of grain-flow rate on accuracy of diverter samplers was studied at an 800-foot per minute speed. The portion of wheat farthest from the leg head had, on the average, a test weight 0.26 pound per bushel heavier than the lot closest to the leg head. At a speed of 650 feet per minute the difference was 0.16 pound per bushel. The sample size drawn by a Gamet diverter sampler was compared to one made by the Strand Company. The Strand diverter drew a larger sample at all flow rates and the difference increased as the flow rate increased. When the opening of the Gamet was made comparable to that of the Strand, the sample size of the Gamet was increased. Cross-sectional mixing in a secondary sampler was studied by parallel blending particles of the same characteristics except color. At least four helices were needed to achieve a good mix. Two mathematical models were proposed to describe axial mixing.

Determining Grain Moisture Content.--Deviations of moisture content, as determined by the Motomco electronic moisture meter and by the oven method, were determined for 350 samples of corn. Results indicate that the relationship between Motomco and oven moistures is not a linear one, and that better charts could be prepared for the Motomco meter by taking into account the curvilinear relationship. Also, density, weight per seed, surface conductivity, electrical resistance of pressed seeds, and conductivity of water extract were determined for each sample. Results were subjected to statistical analysis and showed very low correlations, the highest being between seed density and deviation.



Microwave frequencies of grain studied.--A computer program was developed to reduce the experimental data on reflection coefficient to dielectric properties of grain at microwave frequencies of 700 to 1000 MHz and of 5300 to 8200 MHz. Reflection loss in decibel (db) and transmission losses were obtained for grain sorghum, at 10°C, 20°C, and 30°C and at four levels of moisture content as a function of frequency. The increase in moisture content showed a decrease in reflection loss and a corresponding increase in transmission loss. Investigations of dielectric properties of sorghum, in terms of its transmission loss, return loss, and dissipation loss were completed at frequency ranges between 5.3 to 8.0 GHz and 0.7 to 1.0 GHz.

Some errors in moisture testing.--Errors in oven moisture determinations in corn result from the loss of nonaqueous volatile matter and from chemical reactions between reducing sugars and amino acids producing CO<sub>2</sub>, water and volatile carbonyl compounds, acids, and alcohols. These compounds have been identified and quantitated. In the 15 samples of corn studied, error produced by these reactions ranged from 0.17% to 0.8%.

Performance of rice ratiospect improved.--An experimental electro-optical transmittance sensing head for the rice ratiospect was developed and interfaced with a conventional reflectance-type color sorter to facilitate simultaneous sorting of milled rice based on both reflected and transmitted light. Efficiency of the conventional sorter is improved by 50 to 75% with addition of the transmitted light feature. Research to improve and standardize performance of indent-plate rice sizers showed that amplitude and frequency of vibration, table stability, sizer levelness, plate inclination, and plate cleanliness are important factors contributing to the performance of individual sizers. Also, performance of sizers apparently can be standardized by adjusting frequency.

Rice breakage.--High-speed photographic studies showed that much of the breakage of rice kernels occurs because of random orientation of the kernels as they enter the shelling rolls of the sheller. Radiographic and optical equipment and procedures were developed to evaluate damage before and after milling operations. A mechanical device capable of handling and orienting rice kernels at speeds of approximately 2,000 particles per minute, was developed. The mechanical design incorporates three objectives: (1) accuracy of alignment of belts and wheels accomplished by utilizing milled surfaces and dove-tail joints, (2) repeatability of mechanical alignment after dissassembly, and (3) providing for tension adjustment of belts for a variety of belt

materials and stresses. A prototype machine is in final stages of construction and testing. Optical-electronic length-distinguishing circuits have operated satisfactorily at speeds in excess of the mechanical device. Statistical analyses demonstrate excellent agreement between numbers of particles and weight on a sample of reasonable size.

A standard McGill No.3 milling machine was modified to permit aeration of the rice during milling with conditioned air ranging in relative humidity from 0 to 100%. An experimental miller consisting of a spiral wire brush attached to a rotating shaft was constructed which produced reasonably well-milled rice with little breakage. This process loosened the bran layer, making it more easily removed by a polishing action.

Automatic grain test-weight device.--A test-weight machine previously developed was redesigned primarily to reduce its size. The device was designed to allow a grain sample to flow by gravity during a determination. After filling the hopper all operations are performed automatically. Significant reductions were made in size and weight of the prototype device when compared with size and weight of the first device. An Ainsworth Digimetric Balance Scale is used for weighing, and an MFF Model FP-6 printer is connected to the scale for making print-out records of test-weight determinations. The difference in test weights between the manual and prototype devices was 0.1 pound per bushel, or less.

Weighing individual kernels.--A device was assembled for weighing individual kernels of grain, determining the average kernel weight and generating kernel weight distribution. The device is expected to lead to a more accurate means of predicting the milling yield of grain, especially wheat, and of the malting yield of barley. The device consists of an Ainsworth 1000D Balance, and a Data General 4001 NOVA CPU, with a 4003 4K memory and a 4010 TTY printout attachment. An interface board supplied by Data General Corporation was incorporated into the interface logic unit to maintain flexibility throughout the system. Calibration of the system is nearing completion and plans are being made for an extensive evaluation of both the hardware and the software.

Bleaching of Sorghum and Wheat.--An accurate bleaching method for determining germ damage in sorghum, which requires about half as long as the official method, was developed. The method can be used for determining grain sorghum class mixtures. The method was modified for

wheat by using a cold potassium hydroxide bleach for 20 minutes. This lengthens the time for bleaching, but eliminates certain other problems. This method is being field tested in the Grain Inspection Offices of S&MS. The combined use of sodium hypochlorite and hydrogen peroxide produced a clear white wheat from red wheat with some bran removed.

Rapid test for wheat classification sought.--Analyses of lipids from corn and wheat by thin-layer chromatography revealed no significant differences in composition related to deterioration other than to the quantities of free fatty acids. Absorption of certain dyes by the corn germ shows promise as a basis for a routine inspection test. Sound germs absorb dye and become brightly colored while damaged germs absorb very little dye. Carbonyl compounds from lipids are being investigated to determine their relationship to blight damage in corn.

Methods of measuring grain proteins studied.--There is a need for a protein method as accurate as the Kjeldahl method but much more rapid, less expensive, and simpler. The feasibility of determining protein content of grain by measuring ammonia yield after reduction of nitrogen by hydrogen was studied. A system was developed which could be operated at 1800°F and 100 atmospheres pressure. At 790°C and 28 atmospheres, protein yields of 85 to 98% were obtained, using ground wheat. Presently, ammonia is collected in an aqueous boric acid solution using a high gas flow rate and is titrated by the Kjeldahl procedure. Ground wheat is introduced into the chamber by encapsulating it with cellulose acetate. This research showed that the method is feasible.

Other approaches to protein determination were studied concurrently, namely: (1) The oxidative combustion train system and (2) the Schöniger method. Both involve the conversion of protein to NO<sub>2</sub> and subsequent measurement of NO<sub>2</sub> spectrophotometrically or indirectly or of the NO<sub>3</sub> colorimetrically. Both methods consistently produced poor precision and accuracy. Thus, work was started on a pyrolytic reduction train system. A sample is pyrolyzed at about 660°C and the pyrolysis products carried by H<sub>2</sub> gas through a Ni catalyst to convert any nitrogen-containing compounds to NH<sub>3</sub>. The method proved excellent for amino acids and fair to poor for grains. Precision and accuracy for grains progressively improved with pentane-extracted ground corn. It appears that the oxidative method does not warrant further research consideration, while the pyrolytic reduction method does.

The feasibility of using light scattering, NMR, and gel permeation techniques for studying protein structures of wheat is being explored. Data have been collected on a few protein fractions in relation to variety. A new curvilinear regression equation was developed for the



Udy dye-binding vs. Kjeldahl protein relationship whereby the Udy protein relationship was much improved, especially on low-protein wheats.

Sampling odors of grains.--A schematic flow diagram was developed to permit sampling of grain odors by simple valve operations. The system has been successfully operated, but not yet optimized. The heating-cooling cycle steps need to be streamlined as expulsion of cold water from the jacket of the first adsorber is not uniform. Cooling of the chromosorb is achieved by circulating ambient temperature water through its jacket. Heating is accomplished by passing steam into the jacket. The change in temperature from ambient to approximately 100°C can be achieved in 1 to 2 minutes. A gas-chromatographic partition tube was introduced between the sample collector-concentrator system and the flame ionization detector. Causes of changes in the gas pressure distribution in some parts of the system are being corrected.

Determination of objectionable odors of grains.--Exposure of grain to air for prolonged periods of time prior to sampling of the odor tended to affect the nature of the odor sample obtained. Only after several hours of exposure to air were significant differences found in odor quality. These differences were due primarily to loss of some of the more volatile components. Also, successive odor samples taken from the same sample of grain showed no significant difference with respect to the odor quality. Statistical analysis of the peak areas of the gas chromatograms showed that odors classed as good, sour, and musty can be discriminated; however, discrepancies do occur. These discrepancies are primarily a result of overlapping data in the different odor classes. Design principles of a device for classifying odors of grains was formulated. The device includes a sample collector and concentrator, a gas chromatographic analyzer, and a signal processor and interpreter.

Origin and characterization of mustiness in wheat.--Sensory analysis, gas chromatography of head space gases, and gas chromatography of distillates were used to study the odors produced by fungi and bacteria isolated from wheat and grown on various grains and grain fractions. The fungi produced six to nine distinguishable odors which were classified as musty, fungal, acid, etc. Odors varied depending on the organism and the kind of substrate. Also, certain odors often masked others. Certain peaks were identified as being the principal component of specific odors. The most common odor was termed fungal and was identified as 1-octen-3-ol. Many of the odors produced by the bacteria were different from those produced by the molds.



Progress on development of a method to determine sound grain.--

Sorption kinetic data of damaged yellow corn, obtained at various environmental conditions, were analyzed by surface adsorption and adsorption-phase diffusion. Sorption of water vapor on corn is controlled by surface adsorption mechanisms at an early stage, followed by a diffusion controlling mechanism. Rate constants and diffusion coefficients were evaluated. Infrared photographic data of damaged corn indicate that all colors of objects tend to show yellow or yellowish green. Therefore, it was difficult to see a clear contrast between samples. Thin-layer chromatographs of 21 wheat samples revealed the same pattern. Three of the four classes of compounds observed in this pattern approximate the standard steryl ester, triglyceride, and fatty acid; the fourth approximates a diglyceride. The spot intensity of the triglyceride decreases as does the fatty acid intensity, after an initial increase as the degree of moldiness increases in corn.

General appearance of grains.--A study was conducted to find a method of differentiating the relatively new semi-dwarf varieties of wheat from traditional varieties. Correlations between Hunter a and thousand kernel weight, Hunter a and % large kernels, and Hunter a and medium kernels were poor. Hunter b, yellowness, was negatively correlated with bake absorption, -0.4152. None of the correlation coefficients show promise for predicting quality characteristics from wheat color. The effect of grade on Hunter color was not significant, although both L and b tend to increase as the grade decreases. Semidwarf wheats had higher Hunter chromaticity, a and b, values than conventional varieties. It is not possible to differentiate the wheats by infrared scans of the lipids. Neither triglycerides, diglycerides, free fatty acids, sterols or sterol esters provided a means of distinguishing the semi-dwarf wheat varieties from traditional varieties.

Existing correlations exist between the visually determined color score and the three Hunter readings for clean, dry barley, steeped barley, and malted barley. The dry barley L value is the most efficient predictor of the final malt color. Regression equations relating color score and Hunter readings predicted the color score of steeped barley as well as malt color.

Tests for determining hidden-insect infestation in grain.--The sensitivity of a number of reagents for detecting body fluids of insects in grain was determined. Reagents were selected on the basis of expected reactions with amino acids, phenols, quinones, enzymes, trehalose, and chitin. A ninhydrin-collidine reagent that detected

amino acids was superior to other chemical reagents tested. The reproducibility of tests using the ninhydrin-collidine reagent led to the choice of SS No. 589 Filter Paper. Chemical systems based on the detection by ninhydrin of expressed insect body fluids on a paper test strip were evaluated, by various grain crushing tests, for their ability to detect rice weevil, lesser grain borer, and angoumois grain moth infestations of wheat, grain sorghum and oats. The ninhydrin test, when used with the Dennis-Decker Ninditor, was as reliable as the x-ray method of examination.

Fluorescent techniques for the detection of grain infestation showed promise. The ratio of fluorescent material from insects to the fluorescence of interfering solids from grain, was small and a considerable effort appeared necessary before the method would provide a sensitivity equal to that of the ninhydrin system.

The X-ray hidden-insect detector previously developed, showed a number of weaknesses. Development of a new sensing circuit, substitution of improved amplifiers and redesign of a vibratory handling system for more accurate orientation of kernels greatly improved the detector. The procedure was further improved by utilizing a double vacuum application of a strong solution of potassium carbonate to improve the X-ray contrast difference between infested and uninfested kernels. A correlation analysis of the performance data of the X-ray analyzer gave encouraging results as follows:  $Y=14.037 + 0.728X$ ;  $r=0.988$  (advanced stages of insects).  $Y=20.25 + 0.437X$ ;  $r=0.818$  (immature stages of insects), where Y is the machine determination of infestation level and X is the true infestation level determined by a control method.

New yeast test developed.--A yeast test developed in this study yields results that are not influenced by other constituents such as the interaction of diastase on flour to form maltose. To be practical, the test must relate to the yeasts' ability to ferment doughs. Preliminary tests indicate that the same relative gassing rate measure in the test holds true for doughs containing sugar.

Dust test modified for wheat.--Although dust is a most important factor in judging the quality of domestic and export corn, it sometimes becomes a factor in wheat. The dust test developed for corn is being applied also to wheat with equal success. In the fundamental test the dust is evacuated from a 200-g. sample trapped in distilled water, filtered, dried, and weighed. The rapid method consists of measuring the increase in conductivity and equating it with actual dust by means of a conversion table.

## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Mycotoxins on sorghum.--Sorghum grain was stored under a variety of temperatures (5 to 25°C) and relative humidities (90 to 100%). Aspergillus flavus infected seed was stored at 25°C only. In all treatments, the field fungi remained viable and appeared to inhibit infection by storage molds. Aflatoxins were detected at concentrations of 18 ppb after 2 weeks at 25°C and 100% RH but none was detected in other treatments.

In a survey of 114 samples of sorghum grain from the 1970 crop, aflatoxins in concentrations ranging from 2 to 3 ppb, were detected in 7 samples. A. flavus was isolated from 16 samples, the prevalence ranging up to 11% of infected seed. In addition to A. flavus, A. parasiticus was isolated. Seven of the 40 isolates tested, produced aflatoxin in sufficient quantities to be considered toxigenic. Grain sorghum with 16% moisture was protected from fungal damage by calcium and sodium propionates and sorbic acid. Also, ammonia at 96 mg/L controlled toxigenic fungi.

Mycotoxins on rice.--In a survey of the 1970 rice crop in the Southwest, aflatoxins were found in 3.2% of the samples collected from commercial sources. Concentrations ranged from 5 to 22 ppb. Of 25 samples, more than 4% of the kernels from commercial sources were infected with forms of Aspergillus flavus. Infection ranged from 0 to 57%. Less than 3% of 273 isolates tested for aflatoxin-producing ability were toxigenic. All isolates were identified as A. flavus, A. flavus var. columnaris, or mixtures of the two. A. candidus, when grown on rice, did not produce the characteristic fluorescent toxic compounds found when grown on sorghum.

Toxins produced by *Penicillium viridicatum* and *P. ochraceum*.--Extensive feeding trials with cultures of P. viridicatum have established a characteristic syndrome, with damage primarily in the liver and associated organs. The identity of the toxin(s) is not known, but the isolates used apparently do not produce ochratoxin or citrinin. These two mycotoxins have been reported from P. viridicatum by workers in other countries. Dogs are relatively insensitive to the P. viridicatum but mice, rats, ducklings, swine, guinea pigs, and lambs are all quite sensitive. P. ochraceum produces a syndrome indistinguishable from that of P. viridicatum. Chronic feeding trials with mice for 7 months have not demonstrated carcinogenicity in P. viridicatum.



Southern corn leaf blight.--Conventional drying procedures did not appreciably reduce infection of corn kernels by the Southern corn leaf blight fungus, Helminthosporium maydis. This fungus was more heat resistant than most other fungi present on the material tested. Significant reductions occurred only at drying temperatures high enough to kill the corn seeds.

## Protection Against Insects

### Biology, Ecology, Physiology, and Nutrition

Insect-fungus interrelationships in stored sorghum.--Sorghum grain containing insects and Aspergillus flavus did not readily mold unless the moisture and temperature were increased from normal. The insects (especially the confused flour beetle) transferred from the moldy contaminated sorghum moved slowly, indicating that they were affected by the mold. Rice weevils were more profuse than lesser grain borers; however, their toxin transfer was not as great.

Infested boxcars a source of insects in grain for exports.--Investigations of insect infestations in railcars and their cargoes have revealed that insects living in debris left from previous loads and insects found in visual examinations of cargoes inspectors are directly related. However, visual inspections seldom reveal moth infestations. These occur in about 30 percent of infestable railcars and are seen by inspectors in less than 1 percent. Incomplete data suggest that about 90 percent of boxcars delivering flour and rice to Gulf ports are infestable at the time of loading.

### Biological and Physical Control

Insect resistance in corn varieties.--Plant resistance studies on the maize weevil indicated that total progeny produced was one of the best criteria for determination of resistance. The cooperative study with Plant Science Research Division involved 804 crosses of corn varieties.

Cooperative studies at the University of Georgia indicate that phytosphingosine in the phospholipid fraction and 1,4-benzoxazine derivatives among the glucosides may be associated with stored-product insect resistance.



Insect resistant wheat varieties.--Tests of the resistance of 179 varieties of wheat to the lesser grain borer yielded only one moderately resistant variety. However, 3 of 177 varieties screened against the rice weevil showed resistance.

Thirty-two varieties of wheat, recently tested or currently being tested and grown in Kansas, showed no pronounced resistance to rice weevil attack when stored at 13-percent moisture content.

Insect resistant rice varieties.--Dawn variety milled rice was found to be moderately resistant to lesser grain borers, rice weevils, confused flour beetles, and Indian meal moths. The lesser grain borer resistance also appears in the Dawn rough rice and in rough (but not milled) rice of a Dawn-Belle Patna cross.

Leaf blight increases insect problems in stored corn.--Corn infected with Southern corn leaf blight was found to be more attractive to rice weevils and red flour beetles than blight resistant corn, and more favorable for insect growth and development.

Sex pheromones studies with grain pests started.--Preliminary work has been started towards the biological and chemical characterization of the sex pheromones of the Angoumois grain moth, Indian meal moth, and the rice weevil.

Silica aerogels and saturated muds as grain protectants.--Silica aerogels were found to be as effective applied to wheat as suspension than as when applied as dusts. Saturated muds were highly effective in the control of stored-grain insects.

Diatomaceous earth as a rice protectant.--Diatomaceous earth was effective against rice weevils, but ineffective in controlling confused flour beetles in milled and brown rice because the oils on the surface of the rice kernels saturated the applied diatomaceous earth, rendering it ineffective against the insect. Rice weevils, which were more susceptible to the treatment, were killed before the diatomaceous earth became saturated.

Removal of oxygen from air to control insects in wheat.--An exothermic inert atmosphere generator was used in concrete elevator tanks to create an oxygen deficient atmosphere within the grain mass. Oxygen

concentrations of less than 2 percent held for 24 hours killed the adult confused flour beetles, but not all of the immature rice weevils were killed by exposures of 72 to 96 hours. Germination, milling, and baking characteristics of the wheat were unaffected.

Radiation combinations to control grain insects.--Heating infested grain by microwaves or infrared radiation has been shown to potentiate the effects of gamma radiation on the infesting insects. Infrared heating was more effective than microwave heating.

Low temperature storage for protecting wheat from insects.--In tests of the use of low temperatures to protect stored wheat in a 500-bushel bin, the bulk of the grain could be kept below 60°F., but surface heating allowed an infestation to develop. This method would probably be more effective in larger capacity facilities.

Method for detecting insects inside grain kernels.--Wide-line NMR was investigated as a means of detecting the presence of hidden intragranular insect infestation. Although grain moisture produced an NMR response, the difference between this response and that produced by a rice weevil was easy to detect.

#### Improved Insecticidal Control

Insect control in railway boxcars.--Four tests were conducted in 28 boxcars to evaluate the effectiveness of a Gardona+dichlorvos E.C. mixture. It was found that 4 quarts of a 3.75 percent emulsion per boxcar was effective and left no detectable residues in exposed processed commodities, and air concentrations were within safe levels for workmen.

Protectants for wheat.--In laboratory grain-protectant studies with rice weevils, flour beetles, and lesser grain borers, no new low-mammalian-toxicity insecticide was found that was as effective as malathion. Quarterly, for three years, samples have been drawn for residue analyses from bins of farm-stored wheat, which were treated with malathion. The wheat was treated at harvest and retreated at yearly intervals of storage by farmer-cooperators. Five 40-bushel lots of this wheat were milled in June 1971 at Kansas State University. Malathion residue analyses are being determined on all of the mill fractions. The forthcoming results should show what the millers can expect from different

combinations of repeated malathion treatments on wheat held under normal farm-storage conditions.

Malathion aerosol treatment of wheat, sorghum, and corn.--

Three bins of wheat and 5 bins of grain sorghum were treated with malathion in conjunction with aeration. The malathion was distributed through the entire grain mass. However, not all insects were killed. Malathion aerosols applied to clean corn in conjunction with aeration were highly effective. The same method was less effective when the corn contained a high level of foreign material.

Effects of light on malathion deposits.--Different regions of light have varying photodegradative effects on malathion deposits on glass beads, sorghum grain, and wheat grain. Temperature effects of infrared light produced the most rapid disappearance of malathion, while far ultraviolet light, plant GRO, and near ultraviolet light exhibited a decreasing order of photodegradative activity.

Grain fumigant properties studied.--Complete release of  $\text{PH}_3$  from aluminum phosphide pellets required 40 hours at  $50^\circ\text{F}.$ , and 61 hours at  $40^\circ\text{F}.$ , in 20-liter glass carboy tests.

Corn preservative promising for insect control.--Ortho CS 8945, a high moisture corn preservative, was found to prevent reproduction of rice weevils, red flour beetles, and lesser grain borers.

Dichlorvos resin strips.--Resin strips were placed in nearly 1,000 bins of grain sorghum stored throughout Nebraska to determine their effectiveness in controlling Indian meal moths. About 4.5 million bushels of grain sorghum were involved in the test. The Nebraska ASCS office cooperated in these studies. The treatment, when used in conjunction with the standard ASCS malathion treatment, resulted in effective moth control.

Dichlorvos vapors for control of stored rice insects.--Dichlorvos vapors dispensed with the McGill vapor dispenser were effective in reducing infestations of almond moths and red flour beetles in a rice mill after only two treatments 7 days apart. The treatment was three to 90 times as effective as pyrethrins fogs in controlling caged adult cigarette beetles, adult red flour beetles, adult lesser grain borers, and larval almond moths.

Insecticide combination for protecting rough rice.--Dichlorvos in combination with Gardona (1:2) was effective as a bulk rough rice treatment at 10:20 p.p.m. in eliminating infestations of rice weevils, lesser grain borers, and confused flour beetles. Protection lasted 6 to 12 months. After 180 days milled rice residues were 0.18 p.p.m. Gardona and <0.03 p.p.m. dichlorvos. Surface treatments of the combination at 100 mg./sq. ft. eliminated Angoumois grain moth infestations and prevented reinfestation for more than 6 months.



## MEAT AND MEAT PRODUCTS

## Maintenance of Quality

Lamb carcass shrinkage.--Studies on shrinkage of lamb carcasses with different thicknesses of external fat showed that carcasses with a thick external fat covering, such as found in yield grade 4, shrank less (0.67%) than carcasses with little or no external fat covering, as found in yield grade 2 (0.85% shrinkage). A significant correlation of -0.15 was observed between yield grade and percent shrinkage. A high temperature at time of loading and a large decrease in temperature during transit yielded the greatest increase in shrinkage of these test shipments. A significant correlation of -0.43 was observed between percent shrinkage and temperature change. Some shipments had lamb carcasses with an average internal temperature of 45°F at time of loading; high shrinkage was expected in these carcasses because part of the shrinkage normally encountered in the chill room of the packinghouse occurred during transit. At origin of shipment no differences in surface microbial counts were observed between yield grades or location on the carcass (leg or flank). However, there was a significant difference in microbial counts on carcasses from various packers. These differences were also obvious at destination.

Fresh meat additives.--A cooperative agreement was initiated in June 1971 to obtain data for determining whether additives which are on the G.R.A.S. (generally recognized as safe) list can aid in maintaining the quality of meat. Changes in meat quality characteristics due to the use of additives, including the following, will be studied: Invert sugar, glucose, saccharin, NaCl, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate, citric acid, sorbitol, nicotinamide, black pepper, monosodium glutamate and the oleoresins of some spices including coriander, paprika, and cardamon.

Breaking hot beef carcasses.--A cooperative agreement was recently initiated with researchers at the Oklahoma State University to study handling procedures for muscle, boned from hot carcasses, aimed at optimizing beef tenderness, juiciness, flavor and yield. Attempts to circumvent the mal-effects of cold shortening will be sought.

## Determination of Quality

Pork loin and sow carcass quality.--Three hundred pork loins of varying weight and rib eye area were selected at a commercial meat packing plant. The carcasses from which the loins were selected were evaluated for physical attributes such as muscling, back fat thickness muscle/seam fat score and quality grade. The separable lean, fat and bone of the loins was then determined. Three hundred packer sow carcasses have also been selected, measured, cut and yield data were obtained. Data are being analyzed.

Bull meat quality.--Bulls graded by the same standard as steers were about two-thirds lower in quality grade than steers of the same population when fed the same ration and slaughtered at the same age. The feed conversion and amount of separable lean was greater in bulls. It was possible, by different feeding and management practices, to obtain bulls of the same quality grade as steers at 9, 12, 15, 18, and 24 months. A significantly greater force was needed to shear bull meat than steer meat from 12-, 18-, and 24-month animals, but all meat was considered acceptable. Meat from 15-month bulls and steers was not significantly different. The magnitude of the difference determined by taste panel, though significant for the 12-, 18-, and 24-month animals, was less than 1.1 on a hedonic scale of 10. Differences in other palatability factors were not significantly different. When ribs from bulls were matched with selected ribs of unknown origin but of the same quality grade and maturity, as indicated in the carcass, no real differences were found in tenderness or any other palatability traits.

Feeder cattle quality.--Evaluations of body growth and carcass grade of 5 different body sizes of Charolais and Hereford cattle have been completed. Tenderness and flavor of the Longissimus dorsi from these animals have been determined. Data for the second replicate are being analyzed.

Criteria of bacon quality.--A cooperative agreement was recently initiated to develop criteria which can be used for identifying bacon quality. Approximately 300 pork bellies were selected from Yorkshire and Duroc hogs having high, low, and intermediate amounts of back fat. The bellies are being processed into bacon prior to evaluation. Chemical and physical differences of uncooked bacon will be studied. Rapid methods for quantifying indices of poor quality in uncooked bacon will be sought. Causes of crumbliness, curling, stringiness and uneven cooking of bacon will be identified.

Detection and quality of PSE pork.--A cooperative agreement was initiated in May 1971 to obtain data about palatability and shelf-life stability of PSE (pale, soft and exudative) pork. Compositional differences between normal and PSE pork will also be determined.

Eighty-five hog carcasses were examined for rate of pH decline, using a newly marketed pH pencil, and for appearance of PSE (pale, soft and exudative) muscle. To date, no correlation has been found between rate of pH decline and development of PSE muscle. Rates of hydrolysis of bovine longissimus dorsi and semitendinosus muscles by pronase, a non-specific proteolytic enzyme, were slower than that of the psaos major. On-line methods of detecting PSE pork also are being sought.

Detection of meat extenders.--Electrophoretic resolution of protein bands specific for soybean or milk protein added to processed meat (frankfurters) was carried out on thin slabs of polyacrylamide gel in a vertical direction. Of the various types of added protein, in control batches, only the isolated form of soy protein gave a reproducible band. This is a high molecular-weight band which has a migration rate lower than any found in the protein pattern of processed meat. Because isolated soy protein is only one of various forms of non-meat protein that can be added to processed meat, a more reliable test is necessary.

Meat flavor studies.--Methodology was improved for trapping volatile flavor precursors from lamb meat. Subsequent to gas chromatography separations, sub groups of the volatiles were collected in long capillary tubes heated at one end by a heating tape and cooled at the other end by a block immersed in a refrigerant, establishing a temperature gradient. Mass spectral analysis of these gaseous portions indicated the presence of methyl mercaptan, low molecular weight hydrocarbon fragments, either dimethyl sulfide or ethyl mercaptan and a small amount of carbonyl sulfide in lamb flavor.

Research was recently initiated to relate post mortem muscle structure to tenderness and degree of branching of the glycogen molecule to flavor intensity of beef.

Compositional studies of slaughter animals.--Black Angus steers varying in age from 6 months to 6 years of age were slaughtered and samples were assayed for amino acid, lipid, mineral, palatability and histological changes. Gas liquid chromatographic analyses were completed on lipid samples from 60-month old steers. Mineral analyses were completed, generally, for the 48-month and portion of the 60-month samples. Histological examinations

were completed for the 48-month samples while taste panel analyses were completed for all of the samples. Biochemical evidence was obtained showing that (1) lysosomes are present in the bovine semitendinosus muscle and (2)  $\beta$ -galactosidase, an active and substrate-specific lysosomal enzyme, might be used to follow the course of activation of cathepsin and proteolysis.

A specific and peculiar ratio of chemical components and physical and sensory character was displayed by each of seven beef muscles evaluated from animals of various ages.

Only the content of total protein remained constant among muscles. Increase in fat content during animal maturation from 5 months to 2 years was greatest in the m. infraspinatus (from 1.22 to 4.77%) and in the m. psoas major (from 1.17 to 3.51%). The lowest change in fat content was in the m. semitendinosus (from 0.85 to 1.45%). Connective tissue varied among muscles and was dependant upon carcass quality grade and age but not on sex. Connective tissue content increased in veal (6-8 weeks) to reach a maximum in calves of 5-8 months and then decreased as the animals matured. Muscles of cattle 1.5 to 2 years old had 2.3, 3.4, 3.2, 2.9, 9.7, 3.6 and 5.6% connective tissue, respectively, in the psoas major, biceps femoris, quadriceps femoris, semitendinosus, infraspinatus, triceps brachii, and erectores spinae. Meat tenderness varied in individual muscles but was not related to fat or connective tissue content. Rather inactive muscles such as the psoas major had little connective tissue and were quite tender regardless of age. Moderately active muscles such as the infraspinatus had much connective tissue and were of medium tenderness. Very active muscles such as the biceps femoris had a medium amount of connective tissue and were not tender.

#### Protection from Harmful Microorganisms and Naturally Occurring Toxins

Spoilage bacteria.--Pyrolysis-gas-chromatography was used to numerically characterize species variation among members of the Aspergillus glaucus group of fungi. Analysis of pyrochromatograms indicated PGLC would seem a logical approach to the numerical evaluation of similarity or affinity between strains of both the A. glaucus and A. flavus group. These strains can be placed into taxa on the basis of their affinities owing to the large number of characters which can be used. The degree of variability between nine Penicillium species of the Asymmetrica-Fasiculata group of fungi was evaluated by PGLC. Data showed quantitatively that more variability exists among the penicillia than among four members of the A. flavus group. It was possible to distinguish these strains of penicillia by mathematical analysis of the chromatograms, as well as by classical methods.



Salmonella studies.--Research was initiated to evaluate the use of pyrolysis-gas-liquid chromatography for the detection of salmonellae on meat. Pyrochromatograms were analyzed for the presence or absence of characteristic peaks, peak heights, peak height ratios, and overall similarity among and between members of the Enterobacteriaceae. The technique is capable of differentiating between Salmonella sub genera I, II, III, from sub genus IV (Arizonia), the Bethesda-Ballerup group (Citrobacter), Escherichia, and other enteric group members. Serotypes of salmonellae also were successfully identified by PGLC, but a more rapid means of evaluating peaks, representing fragments of bacterial molecules, needs to be developed.

The incidence and sources of salmonellae and fecal contamination in livestock and resultant meat during slaughter is being determined. The degree to which equipment and sanitation influence cross-contamination of meat is also being studied. Cultures of suspected Salmonella obtained from packing plants have been sent to Meat and Carcass Quality Investigations, Beltsville, Maryland, where they were subjected to biochemical tests and serology for identification.

Detection of unwholesome meat.--Determination of hemoglobin, myoglobin, pH and bacterial flora of samples from properly and improperly slaughtered cattle, sheep and swine indicate that no single technique will suffice to distinguish one from the other. However, hemoglobin-myoglobin ratios of 0.60 or higher in either fresh or frozen samples is indicative of improperly slaughtered meat. It was found that the normal range of Hb/Mb values lies mainly between 0.07 and 0.40. Samples of meat were also studied microbiologically. Because Clostridium septicum is extremely motile and is known to migrate from the intestine into surrounding organs and tissues, this organism also was studied but the organism was not detected either by culture or FA staining techniques in samples from normal animals whether the slaughter method was normal or abnormal, including those allowed to be on their sides for 4 hours before being eviscerated; many unwholesome carcasses can be detected rapidly by the use of the FA technique for detection of Clostridial organisms. The fluorescent antibody technique for detection of Clostridial organisms in meat is rapid and reliable and is, at least, an indicator of improperly slaughtered meat. Bacterial content of improperly slaughtered meat is greater than that of meat properly slaughtered but there is considerable variation in individual samples.

## OILSEEDS, INCLUDING PEANUTS AND COTTONSEED

## Maintenance of Quality

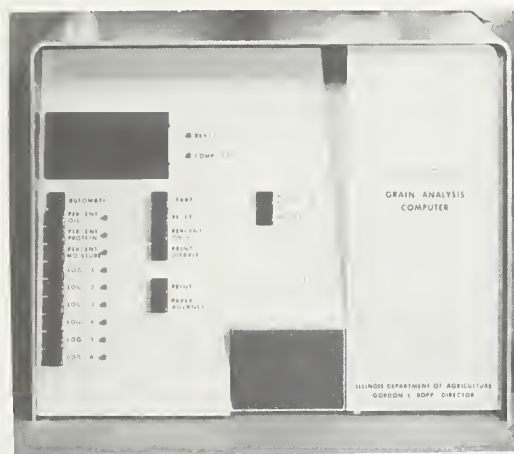
Controlling mold growth on peanuts.--Claims have been made that certain organic acids are effective in controlling mold growth on grain. Some preliminary work was done to determine whether dilute acetic and propionic acids are also effective on peanuts. Peanuts were inoculated with spores of a heavy aflatoxin producer. One group of samples was treated with dilute acetic and propionic acids and another left untreated. Within 4 days, the untreated samples were completely covered with mold. The treated samples had no sign of mold growth after 2 weeks of storage. In studying the effects of moisture on quality factors during certain processing operations and in storage, peanuts were rewetted by spraying with water and by aeration at various humidities. Rewetted peanuts had better shelling efficiency and reduced splits than controls. Those sprayed with water were free of aflatoxin and showed no detectable quality deterioration. Aerated peanuts at the highest humidity showed high free fatty acid content and other quality deterioration. Also aflatoxin was found in the aerated seed.

## Determination of Quality

Protein method for oilseeds.--A procedure for rapid determination of protein in soybean products by a modified biuret procedure was devised. The ground products are stirred with dilute sodium hydroxide solution in aqueous isopropyl alcohol in the presence of copper hydroxide at 70 to 80°C. Absorbance of the reaction mixture after filtration is a measure of the protein content.

Instrumentation for measuring protein, oil, and moisture of soybeans.--A near-infrared reflectance technique has been developed for rapid measurement of the oil, moisture, and protein content of soybeans. Two different optical heads for such an analyzer have been developed. One uses 6 narrow-band interference filters to isolate the specific wavelengths needed for analysis. The second uses three narrow-band interference filters in a tilting arrangement to scan three spectral regions; one for oil, one for protein, and one for moisture. Both versions have been tested in the laboratory with good results giving standard errors of  $\pm 0.35\%$  on oil and  $\pm 0.8\%$  on protein. The measurement requires grinding of the sample, but for samples with moisture content less than 14% the total

sample preparation and measurement can be made in less than 5 minutes. Higher moisture samples present a grinding problem which has not been solved. Two commercial firms are developing prototype instruments based on the above principles. These instruments were evaluated in field tests during the 1971 harvest season.



## Two commercial models of soybean analyzers

In a secondary approach for determining composition of soybeans, infrared attenuated total reflectance (ATR) measurements have been made on prepared soybean samples having a wide range of oil and protein content. The data have been analyzed in several different ways to determine the optimum method for predicting oil and protein content. The sample holder proved reliable and easy to use with optimum results obtained using a force

of 40 pounds on samples which passed the 120 mesh screen. The measurement of ATR absorbance with a baseline correction gave the best correlation with composition ( $r=0.94$  for protein and  $0.96$  for oil). It is concluded that the ATR technique can be used to evaluate the composition of finely ground soybean or similar oilseeds and grain.



Sample holder for ATR studies



Maturity measure of peanuts.--In a study of the moisture profile of a sample of peanuts it was found that moisture distribution is related to both maturity and heat damage. A new maturity measurement for peanuts based on the color of a methanolic extract of green, farmers' stock peanuts was developed. The test is based on the principal that the darker the color of the extract the more mature are the peanuts.

Storage of cottonseed.--A storage study was conducted on cottonseed containing 0 to 110 µg per kg of aflatoxins at 80° and 85°F., both aerated and nonaerated, for 120 days. Moisture content of the seed was 15, 19, and 22%. After 30 days one aerated lot with 22% moisture contained 37,980 µg per kg of aflatoxins. Maximum contamination generally occurred within 60 days. Free fatty acids in the seed continued to increase for the entire 120 days, indicating continued deterioration from enzymic action.

Oil quality of cottonseed and peanuts.--Much of the color in bleached cottonseed oil is due to an alkali-soluble pigment which can be removed by refining. Prime bleached oils have been bleached in this manner from off-colored bleached oils. Bleaching released the gossypol from the alkali-insoluble gossypol pigments that are present in the refined oils. Re-refining of the bleached-oils should be more effective than re-refining the refined oils since the latter contain no free gossypol.

A new procedure was developed for estimating the stability of peanut oil. It is based on the light transmittance of peanut oil at 315mµ before and after heating at 130°C for 1 hour.

Factors affecting peanut quality.--Information was obtained on effects of soil type, geographic location, weather, cultural practices and genotype on peanut quality factors. The quality factors chosen for evaluation were: oil composition, total oil protein, iodine number, oil stability, optical density of the oil, flavor, color, and texture of peanuts. Preliminary results indicate that geographic location of the area in which the peanuts are grown had a greater effect on the above quality factors than soil type, weather, cultural practices or genotype.

Biochemical profiles of peanuts as a quality indicator.--No qualitative differences were observed in volatile profiles of 13 peanut varieties from South Africa, Israel, Australia, Argentina, Taiwan, and 3 United States locations. No quantitative differences were found between peanuts grown within and those grown outside the United States; foreign varieties had higher average pentane values but lower methanol and hexanal values.

Peak ratio data were more sensitive indicators of the observed differences. A dominant difference was found between the poor-quality variety, Pearl, and high-quality market varieties.

The volatile profile technique and organoleptic evaluations were used in studying blanching temperature effects on peanuts and peanut products. Three different temperature parameters were used: high, gradient, and standard. High temperature blanching produced maximum change of the volatile profile. Storage of blanched peanuts resulted in an increased concentration of some volatile components and pronounced flavor changes in the blanched peanuts, suggesting that storage of blanched peanuts may result in the production of off flavors.

#### Protection from Harmful Microorganisms and Naturally Occurring Toxins

Detection of Mycotoxins and associated molds on peanuts.--The millicolumn procedure for detecting and measuring aflatoxins in peanuts, previously developed at the National Peanut Research Laboratory, was improved by making the column twice as long as the original one. The columns are kept dry in a desiccator. The sample is extracted with chloroform only. After filtration, 2 ml of a mixture of methanol-acetone (3:1) are added to the extract after which it is shaken vigorously. A 125 x 16 mm test tube is filled about three-fourths full with the extract and the column is developed. The procedure is satisfactory for raw peanuts and peanut meal. For peanut butter 8 ml of the methanol-acetone mixture is added to the extract before development.

An effective method of detecting farmers' stock peanuts which might contain high levels of mycotoxins is examination of samples for visible growth of Aspergillus flavus. This method, previously reported, has been used under a USDA Marketing Agreement for farmers' stock peanuts since 1968. A recent study designed to measure and improve the method led to the following conclusions: (1) A. flavus identification during routine inspection was correct 93% of the time, (2) aflatoxin in samples from 3,640 lots of segregation-3 peanuts (with visible A. flavus) averaged 203 parts per billion (ppb), (3) aflatoxin in segregation-1 peanuts (without visible A. flavus and less than 3% damage) averaged 14 ppb compared to 281 ppb in segregation-3 peanuts marketed at the same locations during the same period, (4) percent A. flavus kernels in peanuts shelled prior to sampling (LSK) averaged 8 times that in the remainder of samples from segregation-3 peanuts.

Mechanical removal of aflatoxin-contaminated peanuts.--Two-hundred pound samples from 17 commercial lots of shelled peanuts which contained aflatoxin were sorted with an electronic color sorter and then handpicked to remove aflatoxin contaminated kernels. On the average, the electronic sorter removed 8% of the kernels which contained 43% of the aflatoxin originally in the samples and handpicking removed an additional 2% of the kernels which contained 32% of the aflatoxin. Thus, this double separation resulted in the removal of 10% of the peanuts which contained 75% of the aflatoxin. There was considerable variability in the percentage of aflatoxin removed from the various samples. This demonstrates the need for pretesting to determine if aflatoxin can be removed from lots by color sorting and handpicking before the expense of the operation is incurred.

Cause of aflatoxin in stored peanuts.--A survey of peanut storage facilities in the North Carolina-Virginia area indicated that roof leaks and condensation within warehouses caused Aspergillus flavus to grow on farmers' stock peanuts in storage. Apparently the problem was more serious than usual for the 1970 crop, because the weather was unusually warm during the autumn. In some poorly ventilated warehouses, the humidity was so high that the surface of the stored peanuts was covered with a heavy growth of A. flavus. This study indicated that improper storage may be a major cause of the aflatoxin problem in peanuts.

Extent of aflatoxin in peanuts and cottonseed in Southwest.--A survey of cottonseed from the 1970 crop was made by collecting 218 samples from gins and seed houses throughout the crop year. Aflatoxins were found in 10% of the samples in concentrations up to 430 ppb. Members of the Aspergillus flavus group were isolated from 23% of the samples. Five of the A. parasiticus cultures were isolated from samples from the High Plains area of Texas although generally the cottonseed from that area was relatively free of fungi, including field fungi. A. niger was found in 20% of the samples and their prevalence was about the same as that of A. flavus. About 30% of the 1970 crop Southwestern peanuts sampled contained aflatoxin. Of 300 isolates of A. flavus tested, 19% did not produce aflatoxin. The frequency of occurrence of A. parasiticus was 3% in 1970 compared to 1% in 1969.

A survey was made in India to study the levels of aflatoxin contamination in cottonseed. Cottonseed was sampled in the dry areas of Maharashtra, Andhra Pradesh, Mysore, and Gujarat and the humid Krishna and Guntur districts of Andhra Pradesh. Of the 124 samples from the humid areas, 93% were infected with A. flavus. In the dry areas, 68% of the 282 samples were infected. Seventy-five percent of the samples from the humid areas contained aflatoxins. One-half of these showed levels higher



than 500 µg per kg. About one-third of the dry-area samples contained some aflatoxin with 70% containing a level in excess of 500 µg per kilogram.

Detecting aflatoxin on cottonseed.--The time allowed for a complete analysis of aflatoxin in cottonseed meals was reduced from 4 hours to less than 1½ hours. Purification of aflatoxin through silica gel is currently being used by laboratories in the cottonseed industry. This also resulted in a new detection method which can be applied at the field level. Use of a more absorbent material, florisol, combines purification and adsorption of aflatoxin in a one-column operation in which semipurified extract solutions pass downward through a silica gel layer which adsorbs impurities, while the aflatoxin passes through and is adsorbed by a florisol layer. Contamination in cottonseed can be observed at the 5 ppb level.

### Protection Against Insects

#### Biology, Ecology, Physiology, and Nutrition

Indian meal moth spermatogenesis affected by light.--The quantity of spermatozoa found in female Indian meal moths mated with males reared under light-dark cycles was greater than that found in females mated with males reared under continuous light. Of 111 females mated with light-dark (LD) males, 94 percent contained abundant spermatozoa, but only 32 percent of 118 females mated to continuous light (LL) males contained noticeable amounts of sperm. Spermatogenesis in males reared under continuous light was somehow delayed or inhibited. As previous studies showed that egg production was significantly greater in females mated to LD males than in females mated to LL males, the difference in spermathecal content provides strong evidence that the number of eggs deposited is directly related to the quantity of sperm in the spermatheca.

#### Biological and Physical Control

Light and CO<sub>2</sub> combination to control Indian meal moths.--Studies on the integration of methods that adversely affect insect behavior and reproduction produced promising results. The combination of light and CO<sub>2</sub> gas was more effective in reducing Indian meal moth egg production and hatchability than either light or CO<sub>2</sub> alone. In addition, CO<sub>2</sub>



anesthesia of female moths delayed oviposition. The results of these studies showed the potential of integrating complementary methods to achieve better control of the Indian meal moth.

### Improved Insecticidal Control

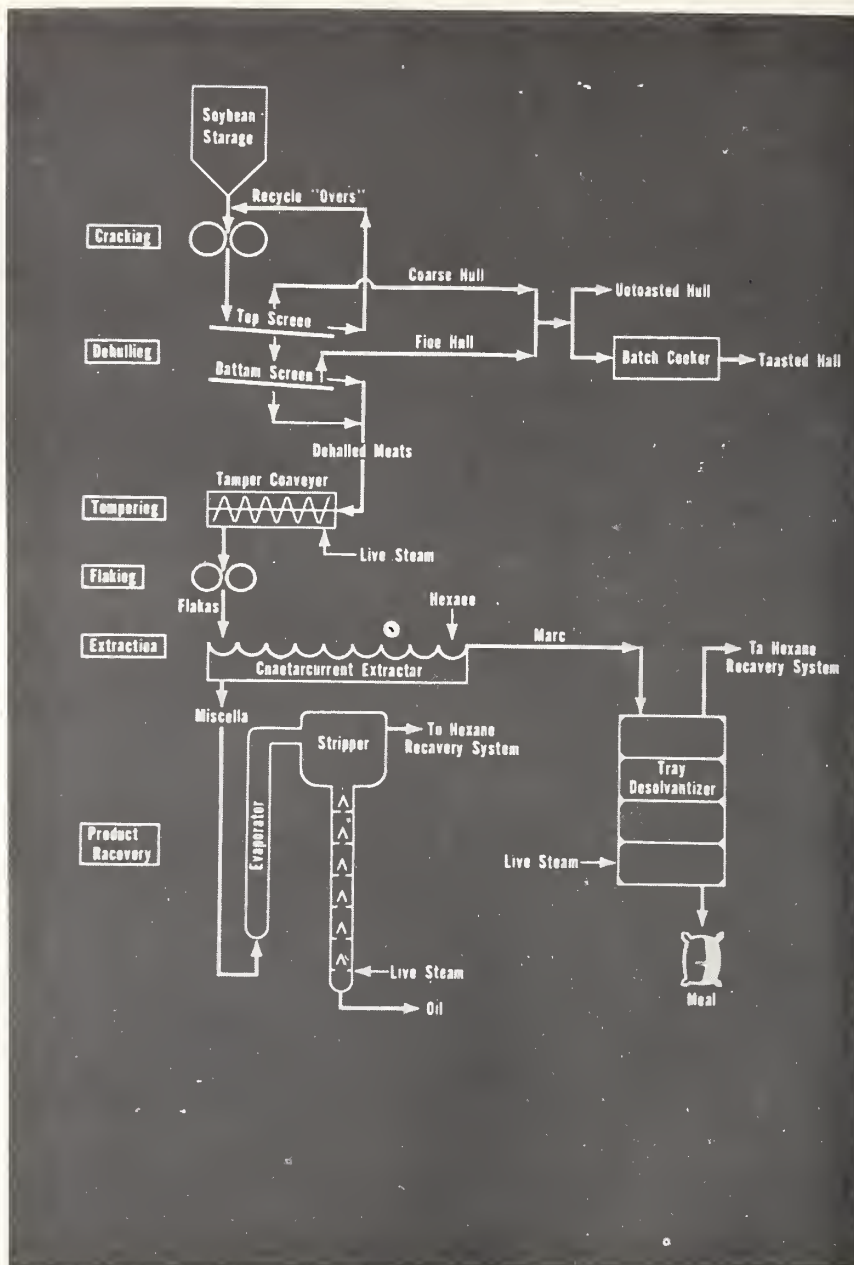
Processing removes residues from soybeans.--Residues resulting from an application of 20 p.p.m. dichlorvos to 12.0 percent moisture soybeans rapidly degraded from 4.55 p.p.m. 1 day after treatment to 0.92 p.p.m. after the 7th day of storage directly before processing. After processing, the hulls contained 5.7 p.p.m., the embryo flakes 0.20 p.p.m. before extraction, and the raw meal 0.05 p.p.m. following oil extraction. These residues disappeared during toasting processes. Crude soybean oil contained about 0.55 p.p.m. dichlorvos but refining and bleaching processes removed the residue.

When soybeans were fumigated with EDC-CCl<sub>4</sub> (75:25), a residue of each component of this mixture remained in both the hull and interior portion of the treated soybeans. Flaking of the dehulled soybeans was ineffective in removing the residues which passed into both the miscella and extracted marc and were subsequently detected in the recovered hexane. The solvent-free oil and meal products contained no residue. Steps in the processing of the soybeans are shown on the next page. These tests were conducted in cooperation with Northern Marketing and Nutrition Research Division.

Fumigant evaluated for soybean insect control.--Fumigation tests were conducted on the Nevada, Iowa, ASCS binsite, to establish a dosage rate and procedure for insect control in stored soybeans. Although 100 percent control was not obtained at a dosage rate of 90 aluminum phosphide tablets, a satisfactory kill was obtained. Complete control could be obtained with an increased dosage rate.

Dichlorvos resin strips control moths in peanut warehouses.--Dichlorvos-impregnated resin strips successfully controlled moths in the overspace of simulated farmers' stock peanut warehouses for 3 months. The strips gradually lost effectiveness during the third month. However, moths were unable to become established in the peanuts in intermediate-scale studies.

In another experiment, dichlorvos-impregnated resin strips controlled moths in a peanut seed warehouse at the rate of 1 strip per 1,000 cubic feet. Only an average of 0.3 moths per day were captured in light traps after installation of the dichlorvos strips, whereas an average of 57.1 moths were caught per day during the preceding period.



Steps in processing soybean oil and meal.

Insect protectants for peanuts.---Gardona-dichlorvos combinations were equal to or better than malathion as a protectant for farmers' stock peanuts during the first 6 months of storage. However, residual effectiveness, at the rates used, decreased rapidly after 6 months, and by 9 months, the combinations were not as effective as malathion. Merchant grain beetles and red flour beetles were the most prevalent insects found in the peanuts. The experiment was terminated after a 1-year storage period.

Phoxim continued to provide excellent protection from insect attack for farmers' stock Virginia peanuts 18 months after treatment. Only a few live insects were found in peanut samples taken from bins treated at the lower rates of application. The standard malathion treatment was not effective for the 18-month period.

## POULTRY AND POULTRY PRODUCTS

## Maintenance of Quality

Improving packaging methods.--To compare microbiological quality of poultry stored in different plastic films, chicken fryers, packaged in unvacuumized polyethylene, unvacuumized vinylidene, or vacuumized vinylidene were stored for up to 13 days at 2°C. Differential bacteria counts were made and rancidity measured at intervals during storage. Total aerobic bacteria and pseudomonad counts were greater in polyethylene than vinylidene packages. Lactobacilli counts were not affected by type of packaging. Microbacterium thermosphactum counts were higher in polyethylene than vacuumized vinylidene, but not different in polyethylene compared to unvacuumized vinylidene. Clostridium perfringens counts did not show a consistent relationship to packaging.

Rancidity determined by the thiobarbaturic acid (TBA) test was greater in polyethylene and unvacuumized vinylidene than in vacuumized vinylidene.

## Determination of Quality

Salmonellae detection.--Some Salmonella serotypes isolated from processed poultry yielded bacteriophage upon induction with mitomycin C. Phage mediated genetic conversion from one serotype to another may possibly explain why different species were usually isolated from antemortem sources (feed, litter, water, cloacal samples) than from postmortem sources (processed carcasses).

## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Relation of odor to microbial growth.--The relationship of off-odor development to microbial growth in liquid whole egg held at 40°, 50°, and 60°F was inconsistent. Gram positive bacilli, Proteus, enterococci, and staphylococci were present in the egg samples, but coliforms and salmonellae were not detected.

Light sensitivity of bacteria.--Broth culture growth of Staphylococcus aureus and Pseudomonas fluorescens was inhibited by a combination treatment of a photosensitizing compound (chlorophyllin Na-K-Cu), then exposure to "daylight" fluorescent lamps. Salmonella spp. were not inhibited. Soaking chicken meat in the photosensitizing compound solution, then exposing to light, did not significantly retard microbial growth.



## SEEDS

## Maintenance of Quality

Storage of damaged seed.--Seeds are often broken, split, bruised and/or otherwise damaged in each step of harvesting, processing or handling. Effects of these treatments on the storage life of seeds are not known. In a study of these problems, the germinability of machine-threshed wheat seeds decreased faster and resulted in fewer living seeds, compared to hand-threshed seeds, when stored for 16 weeks at 25°C and 80% RH or above than hand-threshed seed. These results suggest that care in threshing procedures to eliminate or reduce seed damage may help preserve seed germinability of small grains stored under moist conditions.

Predicting storability of seeds.--Frequently, seedsmen need to know which seed lots should be used during the current season and which can be safely stored for a future growing season. Thus, there is need for a test that will predict present and future performance under field planting conditions. Differences in the physiological quality of seed lots and storage potential are not adequately or consistently evaluated by the standard germination test unless the differences are gross. Accelerated aging techniques were developed for assaying the relative storage potential of lots of 16 different seed kinds. These techniques involve exposure of samples to adverse levels of temperature and RH for 2 to 8 days at 40°C and 100% RH or 2 to 18 weeks at 30°C and 75% RH, followed by a regular germination test. Seed lots that maintained germination well during accelerated aging also maintained germination well in storage under more "normal" conditions. Conversely, lots that were severely reduced in germination by accelerated aging declined rapidly in viability during storage.

Biochemical Deterioration.--Embryos and endosperms of barley and wheat seeds responded differently in regard to metabolic activity and sometimes in an opposite manner when exposed to conditions that induce deterioration. For example,  $^{14}\text{C}$  evolution from  $^{14}\text{C}$ -glucose decreased in the endosperm, but remained constant or increased slightly in the embryo. Respiratory quotients increased with deterioration in intact seeds, but not with isolated embryos or endosperms. As wheat embryos deteriorated they lost the ability to synthesize lipids, polysaccharides, and proteins from glucose and acetate during early hours of germination, but maintained or increased their capacity to use these substrates for carbon dioxide production. Deterioration caused by storage fungi caused coalescence of spherosomes of wheat shoot, root and scutellum cells, and

also shrinkage of the protoplast away from the cell wall and breakage of the plasmalemma. Fungal hyphae (presumably of storage fungi) were found only in intercellular spaces. Cytological examination of organelles in different barley tissues indicate that cellular organelles of mature dry seed endosperm tissue are disorganized whereas organelles of the embryo remain intact and their membrane systems appear well preserved.

### Determination of Seed Quality

Bleaching of lima beans.--Seed vigor of bleached seeds is a major problem in lima bean production. Bleached seeds are less vigorous and give poorer field stands than nonbleached seeds. Low carotenoid levels might explain the relative ease of chlorophyll destruction in some varieties. Of 100 or more lines or varieties analyzed for carotene content, several contained 10-20 times more carotene than the common green-seeded commercial varieties. In preliminary chemical-treatment experiments, 6-benzylaminopurine (a cytokinin), applied to developing pods as a lanolin paste, inhibited seed bleaching without affecting germination. Introduction of high carotene contents to commercial varieties might reduce bleaching and also increase the food value through raising the level of vitamin A precursors.

Germination with thermogradient plate.--Computer programs were developed to analyze and graphically display the germination data collected on a 2-way thermogradient plate. Tests with sideoats grama (Boutleoua curtipendula) showed the temperature combinations at which germination was maximum. Accessions responded differently at each temperature regime. Experiments with sweet corn indicated that the 1-way thermogradient plate may be a useful device in determining differences in vigor of different seed lots.

Vigor test evaluated.--The glutamic acid decarboxylase activity (GADA) test was evaluated as a vigor test for corn and soybeans. Using 18 lots of corn and 17 lots of soybean it was found that correlation of vigor with seedling growth and field emergence was rather poor.

Improvement in germination methods.--Comparisons of present germination methods with new methods developed through research on light mechanisms were made by MQ's Beltsville laboratory and the Oregon State Seed Laboratory, using 20 lots each of 4 cultivars of Kentucky bluegrass seed. Split samples were tested at each location by varying available

light and a number of other factors previously standardized. Results show that low intensity fluorescent light (50 ft-c or less) should be specified for testing bluegrass seed and that prechilling is without additive effect. The following observations were made in studies on temperature and nitrogen effects on germination of western wheatgrass seed in darkness: There was a low response at constant temperatures in H<sub>2</sub>O, improved germination from a single shift of 2 hr. at a high temperature and highest germination at 15-25° daily alternation. NaNO<sub>3</sub> improved germination at 15° constant but not at 15-25°. NaCl, NH<sub>4</sub>Cl, and CS(NH<sub>2</sub>)<sub>2</sub> were without effect at both temperatures.

Site of protein synthesis.--Previously it was thought that ribosomes were the exclusive or primary sites of protein synthesis in the cell. More recent experiments indicated that another type of cytoplasmic particle, the mitochondrion, can also bring about protein syntheses. In some plant tissues the mitochondrial system is an independent and very active site of protein synthesis. Protein synthesis by barley mitochondria in vitro was studied to determine the effects of kinetin, gibberellic acid, indoleacetic acid, and 2,4-D on rates of incorporation of <sup>14</sup>C-labelled DL-phenylalanine. Although some of these plant growth hormones stimulate mitochondrial protein synthesis individually, they are inhibitory when used in combination. Mitochondria isolated from some lots of soybeans supplied by MQ's sponsoring scientist apparently did not incorporate amino acids to any significant extent, whereas mitochondria from other lots were active. The objective of this research is to generate information useful in developing a rapid biochemical test for seed viability and for reducing the conventional germination test period.

Energy source for seed germination.--It has been postulated that some of the energy used in germination of seeds was provided by phytin serving as a donor of phosphate bonds for ATP. An exhaustive, but unsuccessful search for the enzyme, phytindinucleotide phosphotransferase, in pea seed led to the conclusion that in pea seed, phytin did not serve as a donor of phosphate bonds. It appeared that the main supply of energy for the germinating seed is through oxidative phosphorylation (respiration). Consequently, attention was focused on enzymes of the oxidative pathways, particularly cytochrome-c-reductase. In work on cytochrome c, NADH reductase inhibitors of protein synthesis were introduced into dry lettuce seeds, using a new non-aqueous solvent technique. Inhibitors did not affect enzyme activity although they had penetrated the seeds and affected germination and/or respiration. Results were consistent with the view that cytochrome c reductase activity arises by an activation process. The enzyme invertase in germinating lettuce seed is located exclusively in the soluble cell fraction. It is first detectable after 12 hours of germination and then rises very rapidly in activity during the next 12 hours.



Protection from Harmful Microorganisms  
and Naturally Occurring Toxins

New method for detection of Captan on seeds.--The fungicide Captan is frequently applied to seeds to guard against attack by a pathogenic fungus in the soil. Enough fungicide must be applied to provide adequate protection. Over-treatment adds to operating costs and may injure the seed. A standard resorcinol method for Captan was modified to permit estimation of this fungicide on individual sorghum seeds. An important feature of this procedure is its ability to remove dye from Captan. Dye is removed by pouring a benzene fungicide extract through a cigarette filter treated with an absorbent which traps the dye. This method now makes it feasible for seed testing laboratories to routinely determine amounts of Captan on individual seeds.

Rice blight test evaluated.--Over 400 samples of rice seeds were collected from major world, rice-producing areas and evaluated with a new, recently-developed guaiacol agar method for detecting seed-borne Piricularia oryzae, a serious worldwide pathogen of rice. Compared to the standard blotter method, this method is simpler, quicker, and cheaper, and can be used by technicians having a minimum of training.

Southern corn leaf blight.--The blotter method for detecting Helminthosporium maydis, the Southern corn leaf blight pathogen, in corn seeds, was evaluated by 11 members of the Association of Official Seed Analysts Pathology Testing Committee, using 10 samples of infected corn seeds. The best agreement in results was obtained between laboratories staffed by personnel having experience in seed health testing. In a cooperative study, infection, respiration, standard germination, accelerated aging, and tetrazolium tests were performed on 9 samples of H. maydis-infected corn seeds. It appeared from the results that the standard germination test may be a fairly accurate guide for selecting H. maydis-infected corn seed for planting.



## TOBACCO

## Determination of Quality

Enzymatic browning identified.--High molecular weight brown pigments normally form during air-curing of burley tobacco. It was found that symptomless leaves harvested from tobacco plants previously inoculated with either tobacco streak virus or tobacco ringspot virus also contain these high molecular weight brown pigments. The pigment was shown to be a protein-quinone complex resulting from the oxidation of chlorogenic acid. The appearance of the complex followed an increase in peroxidase activity. No obvious correlation between phenol oxidase and formation of the complex was observed.

## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Optimum growing conditions for tobacco fungi.--Light, temperature, RH, and grade of tobacco affect fungi growth. Optimum light conditions for spore production by Alternaria alternata, the brown-spot disease fungus, was alternating light and dark for 12-hour periods. Constant light or dark resulted in few or no spores produced by the fungus. The in vitro growth rate on yeast glucose and tobacco-extract agars of five thermophilic fungi isolated from tobacco indicates Aspergillus fumigatus and a species of Mucor have the fastest growth rate, Talaromyces duponti the slowest growth rate, and Humicola isolans and Malbranchea pulchella var. sulfureae have intermediate growth rates. Sterilized tobacco inoculated with Aspergillus ruber, A. repens, A. niger, A. flavus and Penicillium cytopium was stored at 20, 25, and 30C, at 75, 78, 80, and 85% RH. Fungal growth and moisture content (MC) were evaluated at weekly intervals. At 30C, only A. ruber was isolated, at 25C, A. ruber and A. repens were isolated, and at 20C no fungi were isolated, all after 5 weeks. MC ranged from 17-32%. In another study two market grades of tobacco with natural inoculum were stored and evaluated as above. More growth of A. glaucus occurred on tobacco graded B-4-F at 18.7% MC than on B-4-L at 20.9% MC. Minimum MC for fungal growth was about 21% for B-4-L and 17% for B-4-F. More than 13 additional days' incubation were required for fungal growth on B-4-L to equal B-4-F. A computer program was developed to study storage conditions, tobacco quality, and packaging effects on tobacco deterioration during marketing. A 3-year market survey showed MC and fungi isolated from tobacco marketed in 1968, 1969, and 1970 to be similar. A study to determine when Alternaria alternata infects tobacco leaves indicates the association begins after fungicide treatment in plant

beds is discontinued. Leaf discs from 3-week-old leaves in the field contain almost as much fungus as mature, 7-week-old leaves. Field studies at three locations suggest Difolatan is best of 11 fungicides for control of A. alternata. Late sprays are more effective than early sprays; three applications were adequate.

Synergistic and antagonistic effects of tobacco microorganisms.--Liquid culture extracts from 24 cultures of species of Streptomyces did not show measurable inhibition of tobacco mosaic virus in Nicotiana rustica. In a survey of thermophilic fungi in 23 samples of foreign, 16 samples of domestic cigar, and 20 samples of domestic marketed, flue-cured tobaccos, A. fumigatus was more frequently isolated than other species. Thermophilic yeasts and bacteria were also isolated from these samples. Several isolates of bacteria from tobacco produced materials toxic to Staphylococcus aureus, Escherichia coli, Pseudomonas fluorescens, and Proteus mirabilis. Several isolates produced the toxin only when tobacco was present in the growth medium. Compared to aerobic or anaerobic incubation, micro-aerophilic incubation increased the toxin production for some isolates.

Toxic metabolites from tobacco fungi.--Characterization of aflatoxin growth was continued as the first step in preventing its presence in tobacco. A higher than usual antibacterial activity of aflatoxin extracts from charcoal-treated growth substrates was due to increases in the aflatoxin B<sub>1</sub> to B<sub>2</sub> ratio. Three aflatoxin-producing and one non-producing strain of Aspergillus flavus were examined for their protein patterns using electrophoresis on cellulose acetate membrane strips. Five common 'homologous' protein bands were found for aflatoxin producing strains; the non-aflatoxin producing strain possessed one unique protein band. A 72% reduction in aflatoxins and reduced fungal growth were obtained by adding whole or the chloroform fraction of tobacco smoke condensate into the growth medium. The water fraction of the same smoke condensate stimulated fungal growth and aflatoxin production. The aflatoxins thus produced showed no changes in their characteristics. Aspergillus flavus Fc<sub>3</sub> was used to study the effect of substrate, heat treatment, and UV light on aflatoxin production. Atypical UV absorption spectra and breakdown components of aflatoxins were detected in fungal extracts from cultures heated at 80° and 100°C. A reduction of aflatoxin content was found to be either 12% or 50.21%, in response to either  $6.70 \times 10^3$  erg mm<sup>-2</sup> of near-UV dose or  $10.84 \times 10^3$  erg mm<sup>-2</sup> of far-UV dose, respectively. When aflatoxins were irradiated with UV light, the concentration of aflatoxin decreased proportionately with the increase of far-UV dosage.

Reference standard for mycotoxin production comparison.--A synthetic medium was developed to serve as a reference standard for mycotoxin production by different strains of the same fungus and by different fungi. The medium will serve as a reference to compare mycotoxin production by these fungi on various tobacco types. The medium consists of Eagle's Minimum Essential formula supplemented by l-glutamine, Zn Cl<sub>2</sub>, FeCl<sub>3</sub>, and antibiotics.

### Protection Against Insects

Biology, Ecology, Physiology, and Nutrition

Cigarette beetle response.--In a study of the effects of lowered temperatures on cigarette beetle eggs, it was found that poor hatch occurred when eggs were exposed to 55° F. for 16, 17, 18, 19, and 20 days and no hatch occurred in eggs exposed for 21 days. Ethanol extracts of flue-cured tobacco were found to be more attractive to the cigarette beetle than were extracts of Pennsylvania cigar filler tobacco.

Biological and Physical Control

Pathogens of cigarette beetle.--Two species of bacilli removed from dead cigarette beetle larvae were toxic to the early larval instars. Spores of one species were evaluated at seven concentrations. The following concentrations, in spores per gram, multiplied by 10<sup>6</sup>, killed cigarette beetles at the average rate of: 9.375-53%, 150-85%, and 600-91%.

Sex attractants of cigarette beetle.--Isolation of the pure sex attractant of cigarette beetle females was continued. The attractant was obtained from the isolated females or from a mixture of males and females collected in the lab or from warehouse light traps. Ten micrograms of the pure attractant was obtained. A synthetic compound that showed sex-attractancy was prepared. The synthetic sample showed less potency than the naturally occurring pheromone in bioassay tests.

Light traps for tobacco insects compared.--Lights from 20-watt fluorescent black-light (BL) or black-light-blue (BLB) lamps were similar in attractancy of cigarette beetles. Light from the BLB lamp attracted more species of insects in a tobacco warehouse than light transmitted from a BL lamp.

## Improved Insecticidal Control

Phosphine against the cigarette beetles.--Investigations of phosphine as an alternative to liquid fumigants containing carbon tetrachloride were continued. Resistance of each stage of the cigarette beetle to phosphine listed in decreasing order was pupa, egg, larva, and adult. Phosphine concentration of 500 p.p.m. at 60% RH and 40° F. did not kill all pupae in an exposure of 432 hours. At 60° F. complete pupal mortality was obtained in 144 hours and at 80° F. in 44 hours.

Concentrations of phosphine were monitored inside 40-foot freight containers and in the air surrounding 16 previously fumigated containers during a 7-day transoceanic crossing of a container ship. The phosphine concentration inside the freight containers decreased gradually during the crossing. After 7 days, phosphine inside the containers was generally at trace levels or not detectable. Phosphine was never detected in the air surrounding the containers.

Diffusion of phosphine through plastic film.--Diffusion of phosphine through membranes in 72 hours was 72% for kraft paper asphalt-laminated to kraft paper and creped, 11% for 2-mil polyethylene, and 6% for 4-mil polyethylene. For films of 0.9 mil thickness of polycarbonate, polypropylene, or cellophane the diffusion rate was 0.9%, 0.3%, and trace amounts, respectively.



## VEGETABLES

## Quality Maintenance in Storage

## Controlled Atmosphere Storage

Lettuce.--Research at Fresno has shown that lettuce stored 7 days at 38° F. in controlled atmospheres (CA) with low oxygen (3%) was more severely injured by high carbon dioxide levels (2½-10%) than lettuce in CA with a normal oxygen level (21%). High carbon monoxide (1.5%) in the atmospheres also increased injury by high carbon dioxide. Lettuce stored at low oxygen (3%) combined with high carbon monoxide (1.5%) was the most severely injured by high carbon dioxide.

Radishes.--At Fresno, the market quality of topped red radishes was evaluated after storage for 4, 8 or 15 days at 36.5, 41, or 50° F. in atmospheres with 21, 5, 2, 1, 1/2 or 1/4% oxygen and again after holding for 3 additional days in air at 50° F. Radishes held at 41° or 50° F. stored best in 1% oxygen since the conditions retarded softening and new root and top growth. At 36.5° F., the radishes kept well in air. Roots were injured by 1/4% oxygen during 8 days at 50° or 15 days at 41° F. and by 1/2% oxygen during 10 days at 50° F. Low oxygen injury caused a purplish discoloration and off-flavors and increased decay. Pithiness was independent of oxygen concentrations but increased at 41° and 50° F.

Broccoli.--Color was maintained much better in oxygen concentrations from 1/10 to 1% oxygen than in air when stored at 36.5°, 41° or 45.5° F. followed by a simulated wholesale-retail period of 3 days in air at 50° F. At 45.5° F. the advantage of reduced oxygen was apparent after one week but at 36.5° only after three weeks.

Off-flavors and off-odors were consistently induced by 1/10% oxygen and occasionally by 1/4% oxygen. The off-flavors developed more readily in the pedicels than in the flower buds. The pedicels also showed a white to tan discoloration in lots held 20 days at 36.5° F. in 1/10% oxygen.

Geotropic curvature of individual branches in a head was severe during prolonged storage in air at 2% oxygen at 41° or 45.5° F., but was progressively reduced as oxygen decreased from 1 to 1/4% and was absent in 1/10% oxygen.

Asparagus.--In cooperative studies at Michigan State, it was found that the storage life of asparagus for processing can be almost doubled by using an atmosphere of 5% carbon dioxide plus 8% oxygen. Asparagus held in conventional cold storage (35° F.) turned yellow and showed considerable rot after 3 weeks. That held in CA storage for 30 days was dark green, showed only slight decay and had a good flavor. Prestorage chemical washes were beneficial in reducing decay on the CA-stored commodity.

Green onions.--The use of a controlled atmosphere of 1% oxygen with 5% carbon dioxide prolonged storage life of green onions two or more weeks at 32° F. over that possible in air. Storage in 100% nitrogen at 32° F. also benefited green onions. Film wraps maintained fresh onion appearance for one day at 70° F. by preventing weight loss and wilting.

#### Common Storage

Green onions.--Field trimming of the tops of green onions to about 15 inches considerably reduced weight loss and decay and reduced shipping weight and package size by about 25%. When stored at high relative humidity, but without moisture-proof wrapping, green onions remained acceptable only about one day at 70° F. or 3 days at 32° F. By using polyethylene crate liners or moisture-proof consumer-size wraps and holding at 32° F., green onions could be stored for up to 4 weeks with a shelf life of one day at 70° F.

Sweetpotatoes.--In storage tests, Jewell, A North Carolina release, lost weight and developed intercellular space slowly (11.0 ml/100 ml) to exhibit good storage life. Redman, a Maryland release, and Georgia 41 lost weight twice as rapidly and increased in intercellular space to the point of pithiness, thereby exhibiting poor storage life.

Sweetpotatoes cured at 85° F. and 95-100% relative humidity lost 11 to 13% weight and were 85% marketable after 2½ months storage. At 75° F. and 75% relative humidity, weight loss was 27 to 33% and only 26% of the roots were marketable.

Bulk handling potatoes from storage.--In cooperative tests with the Transportation and Facilities Research Division in the Red River Valley, three bulk scoop bucket types used for removing potatoes from storage were evaluated. The types tested were: (1) narrow edges and low angle sides; (2) wide edges and high angle sides; and (3) variable angle sides. The buckets were used on a 14 horsepower "Bobcat" operating at 3.2 and 4.2 miles

per hour. The bucket capacity ranged from 600 to 800 pounds. Significant variation in tuber damage among replications for each bucket type was found only with the wide edge bucket at 3.2 mph in a loose pile. No significant variation existed as to the amount of damage among buckets. Tuber damage averaged 3.6%.

Mechanical seed cutter evaluation.--All evaluated mechanical seed cutters produced fairly consistent seed pieces of desired size for pre-cutting after careful study and many adjustments made on each machine. Major problems encountered were poor alignment and sizing which caused slivers and poorly shaped seed. Results showed that less than one percent of the mechanically cut seed was diseased or damaged after storage for 2 months in bulk bins. This study proved that large quantities of seed can be cut and treated at 100-160 pounds per minute rates, cured and stored for at least two months with little detrimental effect to the seed. Emergence and stand data showed no difference between precut and fresh seed.

Bulk storage of precut seed potatoes.--In Red River Valley tests, *Fusarium* seed piece decay averaged about 10% in three bulk bins of precut seed potatoes cut in January and March. Temperature, humidity and airflow were controlled during the storage period. Field stand differences between the fresh cut and precut seed were significant at the 1% level with precut seed having the better stand.

#### Quality Maintenance in Transit

Export of radishes.--Improved loading patterns, installation of loading braces, and better quality control at the packinghouse resulted in more uniform transit temperatures, less decay and better quality Florida radishes upon arrival in Europe.

Transcontinental lettuce shipments.--The average carbon dioxide levels in mechanically refrigerated lettuce cars shipped from California to the east coast ranged from 0.4 to 3.9 percent. There was a highly significant positive correlation between the average percent carbon dioxide in the cars and the occurrence of brown stain. Brown stain was significantly more prevalent in cars with modified atmospheres (low oxygen and high carbon monoxide) than in conventional cars when similar amounts of respiratory carbon dioxide accumulated.

Gas exchange test with a railcar.--When carbon dioxide was introduced into a mechanical railcar at a rate comparable to that produced by the respiration of lettuce, the carbon dioxide did not build up when either both A and both B water drains were propped open or when one A and one B water drain were propped open. Propping both A drains open but leaving the B drains closed resulted in an increase in the carbon dioxide level in the car as did leaving all drains closed.

Precut seed potato shipments.--Five test shipments of precut seed were conducted--3 from Colorado to Florida in 90-ton "conditionaire" mechanical refrigerator railcars, one from North Dakota to California in a standard mechanical refrigerator railcar, and one by mechanically refrigerated truck from North Dakota to Washington.

Freshly cut seed shipped from Colorado to Florida in two "conditionaire" cars did not suberize in transit and losses due to bacterial soft rot averaged 95%. Failure in the diesel-electric generator system prevented proper conditions of temperature and airflow to suberize the seed in transit. The third bulk shipment in which the seed was cut and suberized before loading had 0.2% decay in Norchip seed and 4.8% decay in Sebago seed. In field plantings, the precut seed had a 73% stand and seed cut at planting a 40% stand. Average yields were 151 hundredweight per acre from precut seed and 82 hundredweight per acre from seed cut at planting.

In the North Dakota to California tests seed piece decay averaged 14% at destination in a 500 bag precut seed railcar shipment in which load temperatures reached 90° F. in transit.

No decay was found at destination in a North Dakota to Washington truck shipment of 400 bags of precut seed potatoes. The cut seed was stored at 45° F. and 94% relative humidity for 25 days before shipment. Differences in stand for the fresh cut, precut, and whole seed planted from the shipment were not significant.

Disposable pallet boxes for shipping cut seed potatoes.--Both pallet box types tested were in good condition at the end of a 700-mile Maine precut seed shipping test using disposable fiberboard and lightweight wooden pallet boxes. However, when stacked at unloading, the fiberboard pallet box collapsed to the seed level in the box. The use of these types of pallet boxes makes it possible to cut seed directly into boxes, thereby eliminating need for further handling until planting time. Disposable pallet boxes also produce less bruising and losses than found in bulk railcar shipments.



## Postharvest Physiology

Sweetpotatoes.--In North Carolina tests, it was found that the development of sweetpotato decay during storage and loss of culinary quality was proportional to the soil carbon dioxide and pH changes. The application of 1-1½ inches of water per day in September and wet cold soil conditions in late November caused similar changes in carbon dioxide and pH which were correlated with deterioration in sweetpotato quality. Clones differed in response but responses were not the same in November as in September.

In cooperation with plant breeders at North Carolina State, two groups of seedlings were examined for dry matter and intercellular space at harvest to determine inheritance patterns and variation extremes and to evaluate as possible breeding lines. Crosses, back crosses, and open pollinated seedling were evaluated. In all cases, inheritance of dry matter and intercellular space followed the same pattern as observed for other characters; e.g., a multiple or allelomorphic pattern wherein parents high in a character yield seedlings predominantly high in the character and vice versa. Several seedlings lower in intercellular space or higher in dry matter than currently available breeding lines were identified. Some had intercellular space (ml/100 ml of tissue) as low as 0.5. The previous low observed was near 5.0.

Effect of preharvest condition on postharvest quality.--Results of temperature-relative humidity-radiation studies at Fresno indicate that tomatoes can be grown with reasonable success under unfavorable temperatures and relative humidity conditions if adapted cultivars are used. Improper coloration of tomatoes exposed to intense solar radiation is attributable mostly to short-wave (UV) radiation.

Effects of ethylene on head lettuce.--In California tests, lettuce exposed to .01 ppm or higher levels of ethylene for 8 days at 41° F. developed russet spotting after holding at 50° F. for 5 additional days. Pink rib was not affected by these ethylene exposures. Carbon dioxide production by the lettuce was not increased by exposure to the ethylene.

Volatiles from 5 cultivars of lettuce were analyzed for ethylene. The output ranged from .017 to .053 grams per kilogram of tissue per hour, but no definite correlation between the output and cultivar was observed.

## Fundamental Research

Peroxidase isoenzymes in tomatoes.--In related fundamental research conducted at Beltsville, qualitative changes in peroxidase isoenzymes were found to occur in tomatoes during fruit ripening. No catalase isoenzymes were found. Microbodies, as viewed with the electron microscope, appear to undergo change with development of the fruit. As the fruit ripens, the membranes of chloroplasts break down and crystals, believed to be catalase, show up in the microbodies. The significance of these changes in microbodies are not known, but they may be associated with loss of photosynthesis.

Interaction of ethylene with growth promoting hormones.--Earlier research at Beltsville showed that indole acetic acid (IAA) and kinetin stimulated ethylene production in pea seedlings, suggesting a feedback relationship between auxins and ethylene production. Many difficulties were found when published procedures were used to detect IAA in plant tissues. Recently, it was found that use of an alkaline hydrolysis greatly increased the free IAA that could be detected. Further work on valid techniques is needed.

Absciscic acid (ABA) which inhibits growth and promotes dormancy in plants was found to inhibit ethylene production in pea seedlings but had no effect on mature apple fruit. Pea seedlings treated with ABA and ethylene showed additive effects of both treatments. Therefore, ABA and ethylene effects appear to be independent.

## Postharvest Disease Control

Effect of controlled atmospheres on tomato decay development.--Tomatoes inoculated with Alternaria tenuis, Botrytis cinerea, Colletotrichum coccodes and Geotrichum candidum generally developed less decay at 55° or 65° F. in atmospheres with 1/4% oxygen plus 5% carbon dioxide than in air or in atmospheres containing 3% oxygen plus 5% carbon dioxide (fig. V-1). The difference in keeping quality of tomatoes in air and in 3% oxygen was usually small. However, when inoculated with sour rot (Geotrichum candidum), 52% of the tomatoes decayed in 3% oxygen compared to only 13% in air. Sometimes tomatoes that appeared to keep well in 1/4% oxygen decayed rapidly when they were ripened in air at 65° F. This was particularly true with G. candidum where no tomatoes were decayed after one week at 65° in 1/4% oxygen but 99% were decayed after an additional week in air at 65°.

Fig. V-1.--Decay in mature green tomatoes inoculated with decay producing fungi and held 2 weeks at 55° F. in air and in controlled atmospheres.

Storage atmosphere	Percent of fruit decayed by--			
	<u>Botrytis cinerea</u>	<u>Alternaria tenuis</u>	<u>Colletotrichum coccodes</u>	<u>Geotrichum candidum</u>
Air (control)	100	26	79	13
3% O <sub>2</sub> with 5% CO <sub>2</sub>	96	43	89	52
¼% O <sub>2</sub> with 5% CO <sub>2</sub>	9	8	0	0

Red tomatoes were more susceptible to fungal decay caused by A. tenuis, C. coccodes, and G. candidum than fruit in the pink stage while breaking and green tomatoes were least susceptible. Tomatoes inoculated with Botrytis cinerea decayed at about the same rate regardless of their color. Decay lesions were smaller on tomatoes held in 1/4% oxygen than on tomatoes held in air or in 3% oxygen, and smaller on green tomatoes than on breaking, pink or red tomatoes.

In another study, it was found that more than 95% of all mature-green tomatoes that were inoculated with Alternaria tenuis after chilling for 6, 9, 12, or 15 days at 32° F. in air rotted during 2 weeks' storage at 65° F. Holding tomatoes in nitrogen at 32° F. did not reduce decay after removal. No fruits rotted when inoculated after 3 days at 32° F. in either air or nitrogen.

Effect of pre- and postharvest practices on soft rot development.--The effects of varietal susceptibility, field mulching, and postharvest practices of waxing and exposure to ethylene gas on incidence of bacterial soft rot of inoculated mature-green harvested tomatoes were studied in a cooperative project with the University of Florida. Tomatoes of the Walter variety had a higher decay incidence than those of the Homestead variety. Tomatoes of both varieties grown on beds covered with plastic mulch were more susceptible to soft rot than those grown on uncovered beds. Fruit of both varieties that were waxed following inoculation had a higher incidence of decay than those not waxed. In tomatoes that were not inoculated, little difference in decay was found between waxed and unwaxed tomatoes, between tomatoes grown on mulched or non-mulched beds, or between the fruit of the Walter and Homestead varieties. Exposing tomatoes to ethylene gas after harvest did not affect the decay incidence of inoculated or non-inoculated Walter or Homestead variety fruit.

Storage temperature affects fusarium rot development rate.--In Maine, a study was initiated to determine how rapidly *Fusarium* tuber rot will advance in a tuber. Sixty days after tubers were inoculated, it was found that those held at 40° F. had the least decay advancement. Those tubers held at 55° F. and those moved to 55° F. after 30 days at 40° F. showed 99 to 100% rot and more decay advancement in the tuber than those held at 40° F. By moving the potatoes from 40° F. storage to the 55° F. storage, the advancement of the fungus was greatly accelerated. Visual observations showed a dramatic increase in rot development in 14 days in tubers moved from the 40° to the 55° storage. This indicates that apparently sound potatoes shipped to market could show *Fusarium* infection at destination if the in-transit time was 14 days or longer.

Fusarium tuber rot control.--A study is being conducted in Maine to determine the effectiveness of hot water and hot and cold fungicide dip treatments for *Fusarium* tuber rot control. Hot and cold suspensions of thiabendazole (TBZ) at 2 pounds 60% WP/100 gallons gave equal and highest degree of control. When fungicides were applied with a mechanical aerosol fog generator, TBZ gave the best control (87% sound tubers), followed by M-45 (68%), benomyl (56%), Bravo (55%) and Polyram (34%) (fig. V-2).

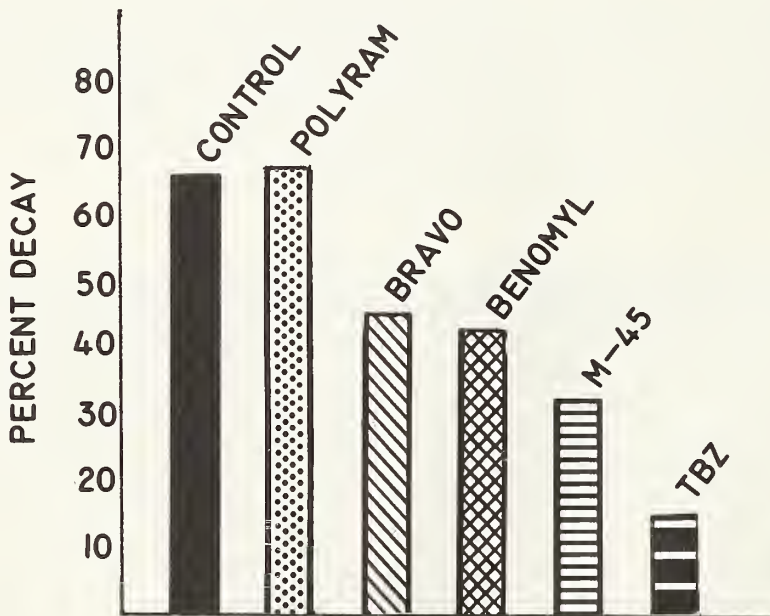


Fig. V-2.--Effectiveness of preharvest aerosol-applied fungicides in controlling decay of potato tubers stored 60 days at 55° F. and 95% RH.



Effect of forced air ventilation on decay.--A second year's replicate in Maine substantiated previous results which showed that a bin with no forced air ventilation had more Fusarium rot than a bin with forced air by 27.7% to 4.8%. Potatoes stored at 55° F. require more added moisture to prevent pressure bruise and weight loss than those stored at 40° F. Washed tubers treated with 500 ppm chlorine and TBZ were brighter and more attractive than those not treated.

Seed piece decay control.--In Maine tests, seed potatoes precut at monthly intervals (January through May) treated and returned to storage had consistently good decay control when treated with M-45 or benomyl dusts (1 lb/cwt.) or a liquid application of thiabendazole (2 lbs/100 gal.). Only one percent average loss occurred over the four-month storage period. The liquid applications were made with a mechanical aerosol fog generator (Microsol) which proved to give control equal to the dusts yet eliminated problems encountered when using dusts; e.g., metering problems and fouling the air with dust particles. This method also makes it possible to apply materials otherwise not acceptable because of formulations that are phytotoxic to cut seed pieces.

Onions--Effect of artificial drying on storage rots.--In a cooperative research project with Cornell University, it was found that onion bulbs artificially dried for 2 weeks with forced air at 85° to 107° F. averaged 3% Botrytis neck rot after 4 months in common storage. Non-dried onions developed 83% neck rot and bulbs held continually at 50° F. developed 100% neck rot in storage. Bacterial soft rot and Fusarium rot increased with an increase in storage temperature. A delay in curing the bulbs resulted in poor decay control in storage.

Onion varietal response in storage.--Twelve varieties of New York State sweet Spanish onions were held for 3 months in common storage. Five varieties developed less than 1% neck rot. In the other varieties, neck rot ranged from 1.2 to 11.6%. One variety, Chieftan Hybrid, was free of bacterial soft rot. In the other varieties, bacterial soft rot ranged from 1.2 to 11.9%.

Chemical control for onions.--Herbisan, Tok, Shed-A-Leaf, and Paraquat were tested with and without stickers and booster oils as top killers to reduce decay of onions in storage. After 3 months in common storage, Botrytis gray mold ranged from 0 to 2.4%, mostly under 1%. Bacterial soft rot ranged from 2.4 to 20.9%. The lots of bulbs showing highest bacterial soft rot were probably injured by the treatments. The non-treated bulbs averaged 4.8%.

Carrots--Storage decay control.--In research conducted in New Jersey, unwashed processing carrots stored for 5 months at 37° F. (80-90% relative humidity) developed decay averaging 78% due to Botrytis, Sclerotinia, Alternaria, Rhizoctonia, and soft rot bacteria. Carrots dipped in water before storage developed 49% decay. Storage decay was reduced to a range of 3 to 5% in lots dipped in 0.1% sodium orthophenylphenate (SOPP), in 900 ppm botran (active ingredients) or in 500 ppm benomyl (active). Dehydroacetic acid, even at the lowest concentration tested (0.1% soln), caused severe injury to carrots.

Samples of processing carrots, dipped in 0.1% SOPP under commercial conditions and held in commercial storage for 5 months developed 23 to 92% less decay than untreated checks. Carrots dipped in fresh solutions of SOPP developed as much decay as those dipped in solutions containing varying quantities of organic matter. Heated SOPP solutions were no more effective in reducing decay than unheated SOPP.

Cantaloups.--In exploratory tests at Weslaco, fungicides were screened for effectiveness in controlling molds on cantaloups. Fruit dipped in 500 ppm triarimol at 135° F. for 30 seconds had the least amount of stem scar and surface molds of the 12 treatments. Reduction of stem scar and surface mold growth after treatment with 500 to 1000 ppm of benlate or thiabendazole (TBZ) was equal to that on triarimol-treated fruit. Melons treated with benomyl (500 ppm) and Cercobin (1000 ppm) had the best general appearance. There were no statistically significant differences in suture browning as a result of the treatments.

Whitewashing melons to prevent sunburn.--Sunburn of Crenshaw melons and vein tract browning of cantaloups were both reduced by whitewashing the fruit in California field tests.

The net heat gain per unit of time (G) during maturation was calculated for both lettuce and melons. The quantity G, derived from measured temperatures and expressed in calories per unit of time, is more meaningful in quantitative comparisons than temperatures alone. Differences in G between normal cantaloups exposed to the sun and those whitewashed for protection against sunburn were determined and correlated with postharvest disorders.

Lettuce--Cultivar susceptibility to carbon dioxide injury.--Lettuce from desert growing areas was found to be more resistant to carbon dioxide injury than that grown in the central coastal areas of California. High carbon dioxide increased the susceptibility of some cultivars to rusty brown discoloration. The disorder was most severe on the Climax cultivar, but was also found on R-200 and Vanguard.

Market Losses of Greater New York Market

Sweetpotatoes.--An internal disorder of wet-type (yam) sweetpotatoes caused considerable concern among wholesalers and retailers in the Greater New York market during 1970-71. There are no external symptoms of this disorder. However, internal cavities and/or discoloration may or may not be present when the sweetpotatoes are cut. When cooked, affected sweetpotatoes often contain hard internal areas which are inedible (fig. V-3). The disorder, apparently of a physiological nature, has been noted in the market the past 3 years but has not reached serious dimensions until this season. This year's losses from the disorder amounted to 6% which was equal to losses from parasitic diseases during the season. It is thought that the disorder might be an atypical expression of internal breakdown and could possibly be caused by wet soils late in the growing season or by low temperature during storage.



Fig. V-3.--Hard rubbery remains of a cooked sweetpotato half after the soft tissues have been removed.

A survey of retail losses in the New York market revealed that physical damage (2.3%) and decay (2.1%) were almost equally damaging in dry-type sweetpotatoes. Physical damage (2.7%) was the leading cause of losses in wet-type roots. The total retail losses were 4.4% in dry-type and 4.2% in wet-type sweetpotatoes. Rhizopus rot wasted 11.2% in the dry-type roots and internal breakdown (6.0%) and decay (mainly Rhizopus rot) caused most of the loss in wet-types.

Cucumbers.--Mechanical damage (1.8%) and decay (1.3%) produced nearly all losses (3.3%) in retail Florida cucumbers. The 5.2% loss in consumer samples after 4 days at 40° F. was due to pulpiness (3.5%), physical damage (1.0%), and decay (0.7%).

Peppers.--Mechanical damage (2.9%), dehydration (5.3%), and decay (1.5%) caused retail losses in Florida peppers. Consumer samples held 4 days at 40° F. had only 2.1% waste. Decay (1.3%) was the leading cause of loss.

Lettuce salad.--Temperatures taken during prepackaging and movement into retail stores illustrate why a lettuce salad is often not marketable. Temperatures were between 55° and 60° F. for most of 24 hours before the salad was placed on the retail shelf. Store shelf temperatures were not much lower. A laboratory holding test with lettuce salad and a chicory-escarole salad mix showed that a lettuce salad was only fair after 1 day at 50° F. The commercial mix was still fair to good after 2 days at 50° F.

Garlic.--Five lots of California garlic showed 0.5% waxy breakdown on arrival in the New York market. However, no increase in severity occurred after 6 months' storage at 34° F.

### Chicago Market Losses

Tomatoes.--Host inoculation, morphological, and physiological studies with bacterial isolates from California and Mexican tomatoes showing bacterial necrosis symptoms indicated that there were at least 6 different bacterial species that could cause the disease.

The retail packout losses for tomatoes in the Chicago market were: 2.98% from parasitic diseases, 0.16% from physiological disorders, and 1.88% from physical damage. Retail shelf losses were: 1.11% from parasitic diseases, none from physiological disorders, and 2.19% from physical damage. Consumer losses were: 0.25% from parasitic diseases, none from physiological disorders and 0.67% from physical damage.



Lettuce.--Internal rib necrosis appeared during the winter on the Climax cultivar. The disorder is associated with rusty brown discoloration but is distinguished from it by the dark-gray-green discoloration about 3 to 4 inches long on the lower midribs. The disease is presumably due to a virus complex of field origin.

Cabbage.--Tipburn was found on New York cabbage. The marginal inner leaves were brown, dry and thin with no external evidence of the disease. No causal organism was isolated.

Celery.--Market losses for celery in retail packout were: 0.21% parasitic diseases, none for physiological disorders and 2.85% physical damage. Retail shelf losses were: 0.47% parasitic diseases, 1.44% physiological disorders, and none from physical damage. Consumer losses were: none from parasitic diseases or physiological disorders, and 2.06% from physical damage.

Cucumbers.--Market losses in retail packout were: 1.10% parasitic diseases, 1.56% physiological disorders, and 2.43% physical damage. Retail shelf losses were: 0.81% parasitic diseases and 0.48% physical damage. Consumer losses were: 1.36% from parasitic diseases.

Green peppers.--Losses in retail packout were: 1.43% parasitic diseases, 2.87% physiological disorders, and 3.77% physical damage. Retail shelf losses were: 0.75% parasitic diseases, 0.63% physiological disorders, and 1.06% physical damage. Consumer losses were: 2.56% parasitic diseases, 3.35% physiological disorders, and 2.0% physical damage.

Snap beans.--Retail packout losses were: 0.21% parasitic diseases, 1.74% physiological disorders, and 1.10% physical damage. Retail shelf losses were: 0.18% parasitic diseases, 1.45% physiological disorders and 0.13% physical damage. Consumer losses were: 1.91% parasitic diseases, 14.98% physiological disorders, and 3.30% physical damage.

### Quality Evaluation

Objective measurement of maturity in tomatoes.--Light transmittance of a series of single wavelengths (510, 560, 580 and 640 nm) and the difference of light transmittance between pairs of wavelengths (510-560, 510-580, 510-640, 560-600, 560-640, 580-640 and 600-690 nm) were measured to separate

various classes of mature-green Homestead tomato fruits. Single wavelength measurements were made to determine non-valid  $\Delta OD$  values which occurred at times with very dense fruit.

The  $\Delta OD$  of 560-600 nm or 510-640 nm appears good for separation of immature to mature green fruit, with the first pair being slightly better. A  $\Delta OD$  of 600-690 nm gave good separation of fruit ranging from breaker (internal or external) to ripe red. Open locules in immature green fruit occasionally caused erroneous  $\Delta OD$  values and accordingly the fruit was categorized as a ripe fruit. Such fruits were effectively separated by using a 0.95 specific gravity ethanol solution.

Uniformity in mature-green tomatoes.--At Beltsville, research was initiated to develop practical means of sorting green tomatoes for a narrower range of maturity. Visual and instrument techniques are being evaluated. In simulated export shipping tests, it was shown that the range of maturity of green fruit normally packed is too wide to allow uniform ripeness on arrival in foreign markets.

Ripening tomatoes.--In other studies at Beltsville, four tests were conducted to evaluate ethylene at concentrations as high as 8000 ppm for ripening mature-green tomatoes at 70° F. Results to date indicate little or no value from the ethylene for hastening ripening. Under the test conditions, natural ethylene from the tomatoes may have been adequate for ripening.

Development of non-destructive maturity indices for cantaloups.--The quality of Maine Rock hybrid, PMR-45, and Edisto variety cantaloups grown at Beltsville were evaluated objectively and subjectively. Melons harvested at "full slip" varied widely in quality and ranged in soluble solids from 5 to 16%. About 30% of PMR-45 and Edisto melons (commercial varieties) contained less than 9% soluble solids.

Maine Rock, a garden variety, was preferred over the other two varieties by the taste panel. The flesh color near the cavity correlated reasonably well with soluble solids especially  $L$  (-0.75) and  $a_L$  (0.74). On the other hand, the skin color ( $L$ ,  $a_L$ ,  $b_L$ ,  $a_L/b_L$ ) which is a desirable area for non-destructive objective measurement, correlated poorly ( $r = 0.5$ ) with soluble solids. Soluble solids and texture (measured by Instron or taste panel scores) were not closely related. The soluble solids scores of PMR-45 and Edisto correlated reasonably well with taste panel sweetness scores ( $r = 0.69$ ). The relationship was closer at soluble solids values between 5 and 12% than at higher values. Other flavor factors probably influenced panel scores for melons with soluble solids above 12%. No significant correlations were obtained for skin color versus sweetness, light transmission versus sweetness, and light transmission versus soluble solids.

X-ray measurements.--X-ray inspection is recognized as an important method of nondestructive testing, especially for such defects as granulation in oranges or hollowheart in white potatoes. Tests were conducted on potato tubers having various degrees of severity of internal hollowheart and also on normal tubers. X-ray pictures were 100% effective in exposing the hollowheart condition in the defective tubers. X-ray photographs taken of tubers submerged in water enhanced the radiographic contrast between normal and hollowheart potatoes. The water surrounding the tubers served as a masking agent. Further work is planned in this area to explore the feasibility of automatic sorting of such potatoes during handling in a water stream.

#### Protection Against Insects

Sweetpotato weevil control.--Cooperative research with the Louisiana State University to find better methods for controlling sweetpotato weevils in stored sweetpotatoes recently was initiated. Control methods that do not depend on DDT will be developed. Areas of research will include the investigation of chemicals, temperature, resistant sweetpotato varieties, and natural attractants for sweetpotato weevil control.

## WOOL AND MOHAIR

## Determination of Quality

Physical properties studied.--Mechanical properties were determined on 50 wool samples, obtained from four major wool producing regions in the U.S. Softness was correlated with felting power ( $P < .01$ ), Young's Modulus ( $P < .05$ ) and percent reduction in stress ( $P < .05$ ). A device suitable for use in diameter measurement with the Coulter Counter was developed for sectioning fibers to lengths. Although correlations were significant ( $P < .01$ ), results obtained with the Coulter Counter appear to give finer diameters and more accurate results than the American Society for Testing and Materials (ASTM) method.

Chemical properties studies.--Factors such as the effect of cross linking on physical properties of wool are being studied. The influence of rearrangement of the disulfide bonds of wool or their permanent rupture on wool characteristics will also be studied. Geographic areas for wool sampling were established and samples from nine states in India were collected. Sampling of Spring wool will be completed in 1972 and characterization of the fibers will begin.

## Protection Against Insects

## Nontoxic Mothproofing

Preliminary evaluation of protectants.--Bay 91273, an organophosphate insecticide of low mammalian toxicity, was the most promising of 21 new experimental compounds and 31 Western Marketing and Nutrition Research Division treatments evaluated as mothproofers.

Residual effectiveness of protectants.--Gardona applied to woolen cloth in practical home-type applications resulting in initial deposits of 0.14 to 0.38 percent by weight still satisfactorily protected the cloth against black carpet beetle larval feeding after the treatments had aged 3 years. A deposit of 0.50 percent Gardona by weight applied to rubberized hair as an emulsion spray protected it against black carpet beetle larval feeding even after the treatments had aged 15 months.



Cloths treated in a bath containing 0.005 percent actual Penick SBP-1382 were still protected after aging 15 months. Woolen carpet samples treated with oil solution sprays of Aliquat 336, Ciba C-9491, Gardona, methoxychlor, and Perthane at 0.50 percent by weight and not subjected to walking traffic or vacuuming were satisfactorily protected against feeding of black carpet beetle larvae for 9 months after treatment. In contrast, after treated samples were subjected to heavy walking traffic and weekly vacuuming for 6 months, only those treated with Ciba C-9491 were still satisfactorily protected.

## INSECT CONTROL IN MARKETING CHANNELS--CROSS COMMODITIES

## Biology, Ecology, Physiology, and Nutrition

Indian meal moth metabolism.--In basic research on pheromones, hormones, and enzyme systems in stored-product insects it was found that Indian meal moth larvae increased their stored fat during the last larva instar from 5 percent to 20 percent of the live weight. Dietary lipids account for part of this, but synthesis of fatty acid from nonlipids was found to contribute significantly to the accumulation. Fat storage decreases before the larvae pupate. Addition of juvenile hormone, or similar acting chemical, to the larval diet prevents pupation. The insects, therefore, do not reach the adult stage and thus do not reproduce.

Sex pheromones.--A method has been developed which ensures that sex pheromones can be rapidly and quantitatively separated from potential masking substances that occur in normal extracts. The technique involves a modification of the molecular exclusion principle, which is ordinarily used for separating proteins of different molecular weights. The method has been refined to accommodate microgram quantities of sex pheromones, which have been obtained at nearly 100 percent recovery from mixtures containing large amounts of lipids.

The stimulatory sex pheromone of female Indian meal moths was identified as 9,12-tetra-decadien-1-yl acetate. The sex pheromone of Attagenus elongatus has been partially purified. The pheromone appears to be a free fatty acid.

Response of two grain beetle species to moisture.--In laboratory ecological studies the merchant grain beetle showed a hygropositive response over a much greater portion of the RH scale and had a stronger response at the upper end of the scale than did the sawtoothed grain beetle. Both beetle species showed a hygronegative response at the upper end of the scale, but that of the merchant grain beetle was less intense than was that of the sawtoothed grain beetle. Knowledge of the responses of insects to humidity alternatives could be used to lead insects into traps or to make stored products less attractive to the insects by the use of moisture control.

Effect of female sex pheromone on male black carpet beetles.--Black carpet beetle males were found to exhibit sensory habituation upon exposure to small quantities of female sex pheromone. After exposure to 0 mg., 1 mg., and 100 mg. of pheromone for 24 hours the males were removed from the pheromone for 1 or 4 hours and then bioassayed. The response was 90, 75, and 15 percent, respectively, after 1 hour, and 95, 75 and 35 percent, respectively after 4 hours. The males' location of and mating with females after removal of portions of the antennae was investigated. The following percentage of males mated: 94 percent of the controls; 54 percent of the males with one antenna removed; 11 percent of the males with both antennal clubs removed; and 3 percent of the males with both antennae removed. Males continuously exposed in petri dishes to 1,000 or 10,000 female equivalents of pheromone for 1 hour took significantly longer to find females than did the controls. Most of the males in the treated containers did mate, however, The male mating attempts in treated containers appeared to be disoriented. Male black carpet beetles were attracted to and attempted to mate with shoe lace knots coated with small amounts of sex pheromone. The male, however, still consistently found a female placed among 30 pheromone-coated knot decoys.

Fatty acids affect the hide beetle.--Studies on the influence of fatty acids on ovarian development and reproduction in the search for antimetabolites for use in stored-product insect control have shown that caprylic and capric acid cause embryonic mortality in the hide beetle. These chemicals do not usually occur in the food of this insect. When either of these fatty acids are fed to the female beetles, substantial amounts are incorporated into the eggs and the embryo is killed.

Amino acids in stages of the cigarette beetle.--In studies of the amino acid and vitamin requirements and deficiency effects on insect physiology, 21 free amino acids were determined in cigarette beetle eggs and adult males. The number of amino acids varied between 16 and 20 in other stages with the fewest in the second instar larvae. The knowledge of the specific amino acids in the insect at various stages provides for a better understanding of the morphogenetic events going on inside the body, possibly of the methods by which the insect maintains osmotic pressure and buffering action of body fluids, and perhaps of ways in which conditions can be manipulated to the detriment of insect development. The knowledge may also be useful in the taxonomy of insects.

## Biological and Physical Control

Transmission of Indian meal moth parasite.--Data on the transovarian transmission of Nosema plodiae in Plodia interpunctella have shown that all stages of this pathogen were not transmitted with equal frequency. Moreover, eggs usually harbored predominantly only one stage of the pathogen. Histological studies indicated that N. plodia first invades and multiplies in nurse cells before passing into associated oocytes.



Navel orangeworm pathogen studied.--Another part of the research directed towards finding suitable pathogens for microbial control of stored-product insects involved study of the life cycle of a Rickettsiella that attacks the navel orangeworm. Stages in the life cycle were examined in ultrathin sections of tissue of navel orangeworm larvae. Primary cells bounded by a single membrane were the first stage observed. Coarsely granular secondary cells, which had electron dense nuclear equivalents and were bounded by two membranes, differentiated within the primary cells. The primary cells developed into vesicles in which the secondary cells developed to give rise to inclusion body crystals and long chains of minute cells. These minute cells finally form the infective cells of terminal infections.

Webbing clothes moth virus.--In a histopathological and ultrastructural study of a nuclear polyhedrosis virus of the webbing clothes moth, Tineola bisselliella, polyhedra development was observed in cell nuclei of the hypodermis, fat, tracheae, gut, Malpighian tubules, ganglia of the ventral nerve cord, and tissue associated with the muscle. Electron microscope observations show that the virions are probably transported from the gut lumen to nuclei of the columnar cells by means of cytoplasmic vesicles.

CO<sub>2</sub> for cowpea weevil and wax moth control.--In experiments to control insects by modifying the concentrations of gases in the atmosphere, it was found that cowpea weevil eggs, 0 to 24 hours old, were controlled (more than 90 percent reduction in adult emergence) by a 2-day exposure to an atmosphere containing 62 percent of carbon dioxide and 9 percent of oxygen. It was also found that a 5-hour exposure to a 99-percent concentration of CO<sub>2</sub> at 100° F was effective in controlling all stages of the greater wax moth. A 10-hour exposure to this concentration was effective at 75-85° F.

Infrasound effects on Indian meal moths and flour beetles.--Exposure to infrasound at 10 and 13 Hz at 102 db was found to increase the oviposition of Indian meal moths by 137 and 206%, respectively, above that of the controls. In tests conducted in simulated silos emerging females tended to lay eggs in the vicinity of the sound source.

Sonic energy of 460 Hz at 84 db attracted adults of the confused flour beetle and reduced oviposition on the media by 78%.

Hormones prevent development of Indian meal moths and flour beetles.--Synthetic preparations of the natural juvenile hormone (ENT-33972a and Ayerst's AY-22342-2) were effective at 100-250 parts per million (ppm) in the diet (6-15 nanograms/insect oral dosage) in preventing pupation and at 25 ppm in the diet (1.5 nanograms/insect oral dosage) in preventing eclosion of Indian meal moths. Two compounds, ENT-Nos. 70119a and 70357, were 10 times more effective than were the natural juvenile hormone preparations. Zoecon's ZR-233 and Stauffer's R-20458 were about as effective as the natural hormone preparations. Sixteen additional compounds were evaluated and were found to have relatively little or no juvenile hormone activity.



Last-instar red flour beetle larvae were placed in media containing various concentrations of candidate juvenile hormone-mimicking compounds. Hoffman LaRoche's ENT-70119a and Stauffer's R-20458 were among the most promising, with 1 ppm of either preventing normal development of the insects. An initial concentration of 5 ppm of ENT-70119a was required to prevent insect development after the treated media had aged about 6 months. Hoffman LaRoche's ENT-33972a and Ayerst's AY-22342-2 (both synthetic preparations of natural juvenile hormone) prevented development at 10-25 ppm. The cigarette beetle was more resistant than the red flour beetle to the hormones. Sterility was not evident in normal-appearing adults emerging from hormone-treated media.

Hymenopterous parasite to control Indian meal moth.--Studies have shown that maximum effectiveness of Bracon hebetor in parasitizing Indian meal moth larvae was at the level of 250 female Bracon per 1800 larvae, at which 97 percent of the larvae were killed.

Granulosis virus tested against Indian meal moth larvae.--Trials conducted with first instar Indian meal moth larvae exposed to granulosis virus capsules on a bran diet showed that there was a loss in virus activity as a result of formulation.

Insecticides more effective against irradiation insects.--Tests have shown that the toxicity of malathion, carbaryl, or lindane to adult Callosobruchus analis increases if the insects are irradiated with 25 krad of gamma radiation one day before, after, or during insecticide treatment.

Genetic transmission of gamma-radiation induced lowered fertility of Indian meal moths.--A significant finding that may lead to a useful nonchemical stored-product insect population suppression technique has been demonstrated. Indian meal moths that developed from larvae irradiation at a selected dosage produced fewer offspring than did nonirradiated moths. The decrease in reproduction was even more pronounced in the two subsequent generations, with no additional irradiation. When males from subsequent generations of the irradiated group were mated with females from an unirradiated group, the percentages of reduction in offspring were 72, 89, and 47% for the F<sub>1</sub>, F<sub>2</sub>, and F<sub>3</sub> generations, respectively.

#### Mode of Insecticide Action and Development of Resistance

Resistance to insecticides.--Red flour beetle adults, Indian meal moth, and almond moth larvae that are highly resistant to malathion showed little or no resistance to synergized pyrethrins, Dowco 214, or SPB-1382 in laboratory tests. These insecticides with low mammalian toxicity may become suitable replacements for malathion in situations where malathion will no longer control the insects.

DDT resistance in khapra beetle.--Studies are elucidating the nutritional requirements of the khapra beetle. The knowledge gained may help to explain the difference in susceptibility to DDT of the larvae and adults of this insect species. Results of several tests showed that the khapra beetle does not metabolize DDT. However, previous work has shown that DDT penetrates adult Trogoderma cuticle more rapidly than it does larval cuticle. In addition, larvae retain less DDT in body tissue and nerve cord and excrete it at a faster rate than do adults.

### Improved Insecticidal Control

Lemon oil component toxic to cowpea weevils.--A fraction of lemon oil that was found to be toxic to cowpea weevils was determined to be nonterpene and nonalcohol. In further purification of the fraction, two chemical components were isolated which may lead to development of a natural-product chemical for stored-product insect control.

Pretreatment of masonry surfaces to extend insecticide life.--In preliminary tests, treatment of masonry surfaces with paraffin wax did not extend the residual effectiveness of malathion sprays against flour beetles, but the treatment did extend the effectiveness of Gardona up to 22 weeks. A 10-percent propionic acid surface treatment extended the malathion effectiveness up to 7 weeks.

Preliminary evaluation. Evaluations of new compounds for the control of stored-product insects showed that five of 48 tested as repellents, 10 of 34 tested as direct-contact toxicants, 21 of 28 tested as residue toxicants, and eight of 13 tested as vapor toxicants were promising for followup studies.

### Insect-Resistant Packaging

New chemical barriers to insects.--In studies conducted for the purpose of developing improved insect-repellent treatments to keep insects from infesting packaged foods, it was found that a new chemical, SBP-1382, alone or synergized with piperonyl butoxide provided packages with better protection against insect penetration than did synergized pyrethrins. The latter is the only insect-resistant treatment presently approved for use on packaging materials such as multiwall paper flour bags.

New barriers to chemical migration.--The prevention of migration of chemicals into foods when the chemicals are applied to packaging materials to avert insect entry is a problem undergoing extensive investigation. A completed 18-month storage test demonstrated that the most effective barrier to migration of insect-resistant treatment chemicals were greaseproof paper and saran over styrene butadiene-coated kraft paper. Use of these materials for packaging should help protect the safety of our food.

New insect-resistant textile bags.--In tests to develop insect-resistant textile bags, four types of construction of textile bags that prevented migration of treatments of pyrethrins into commodities were effective in preventing insect infestation during 9 months' storage in rooms in which large populations of stored-product insects were maintained. The four constructions that prevented insect infestation were as follows: (1) insect resistant (synergized-pyrethrins-treated) cotton (IRC)/ethylene vinyl acetate (EVA) plus wax/saran-coated kraft, (2) spunbonded polypropylene/ethylene vinyl acetate plus wax plus synergized pyrethrins/saran-coated kraft, (3) IRC/EVA plus wax/extensible kraft and (4) spunbonded polypropylene/EVA plus wax plus synergized pyrethrins/extensible kraft. Two other materials that prevented insecticide migration were: (1) synergized pyrethrins-treated kraft/saran-coated kraft/untreated cotton, and (2) IRC/unplasticized polyvinyl chloride film. These constructions, however, did not prevent insect infestation during the total storage period.

### Fate and Effect Residue

Analyses made.--A total of 4,327 samples of various stored products that had been treated in Branch laboratories in experiments for prevention or control of insects were analyzed in the past year. The percentage distribution of the analyses was: Piperonyl butoxide--64.4; malathion--13.8; Gardona--5.9; inorganic bromide--5.2; phoxim--3.6; dichlorvos--3.4; Penick SBP-1382--2.4; and others --1.3.

New analytical methods developed.--A chromatographic colorimetric method for detecting and measuring piperonyl butoxide in flour has been developed and reported. The insecticide residue is extracted with pentane and chromatographed on a column of Florisil, with two successive eluting solutions of ethyl acetate in pentane. Previous methods for piperonyl butoxide lacked the degree of sensitivity required for determination of low residues in flour or in products that contain oils, waxes, or other interfering substances.

A method has been devised for the analysis of phoxim and some of its metabolites on stored wheat. In this method the phoxim is extracted with pentane. After a silica gel cleanup, the sample is analyzed by thin-layer chromatography. This TLC procedure can be used to determine not only the parent compound but also the O analog, O, S-diethyl isomer, corresponding acid, and the oxime. Currently a fluorescence method, which should lower the quantitative detection limits, is being investigated. Phoxim is being synthesized using C-14 and P-32 to facilitate the determination of its fate and rate of degradation.



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## CRIS WORK UNITS

## Market Quality Research Division

[\*\* Initiated during reporting year. \* Terminated during reporting year.]

Number	Title	Location
FC-2	:Laboratory methods for estimating seed vigor	:Beltsville, Md.
FC-3	:Verification of varietal designations of crop : seed	:Beltsville, Md. :
FC-4	:Development of methods for routine testing of : seed for pathogenic fungi	:Beltsville, Md. :
FC-5	:Study of environmental conditions on seed : germination	:Beltsville, Md. :
FC-7	:Relation of fungi to quality of seeds, grains, : and their products	:Beltsville, Md. :
FC-9A*	:Predicting the storage life of seeds	:State College, Miss.
FC-12PL	:Biological basis of physiological phenomena in : seed germination	:Jerusalem, Israel :
FC-18*	:Measuring fungal contamination and metabolites : in grain	:Beltsville, Md. :
FC-26*	:Measuring protein content of grain sorghums : and other feed grains	:Beltsville, Md. :
FC-27	:Evaluation of the quality of gamma-irradiated : cereal grains	:Beltsville, Md. :
FC-28 ,	:Relation of lipids to grain soundness and : quality	:Beltsville, Md. :
FC-32C	:Development of a method to determine sound grain	Manhattan, Kans.
FC-33C*	:Optical properties of grains and foreign : materials associated with grains	:Minneapolis, Minn. :
FC-34C	:Develop a method and device to isolate and : concentrate the germ of grains	:Manhattan, Kans. :
FC-38*	:Sanitary quality and wholesomeness of "further : processed" poultry products	:Beltsville, Md. :
FC-39	:Control of <u>Salmonella</u> on fresh market poultry	:Beltsville, Md.
FC-40*	:Methods for detecting salmonellae in poultry : and egg products	:Beltsville, Md. :
FC-41A*	:Reducing <u>Salmonella</u> contamination of broiler : chicken carcasses during processing	:Newark, Del. :
FC-46	:Commercial drying, handling and storage of : peanuts	:Raleigh, N. C. :
FC-49	:Rapid detection of molds and/or aflatoxin in : peanuts	:Raleigh, N. C. :
FC-55	:Meat flavor as a palatability standard	:Beltsville, Md.
FC-56	:Objective criteria of meat quality	:Beltsville, Md.
FC-58C	:Identification of meat slaughtered by approved : methods	:College Station, Tex. :
FC-62C	:Fineness and softness as quality factors of : wool	:Laramie, Wyo. :
FC-65	:Effects of previous history of cotton lint on : market quality	:Clemson, S. C. :



FC-68	:Cotton fiber testing instruments and techniques	:Clemson, S. C.
FC-70*	:Methodology studies for development of improved cotton spinning performance tests	:Clemson, S. C.
FC-71A	:Measuring factors affecting spinning performance and product quality of cotton	:Clemson, S. C.
FC-72	:Apparatus for blending a sample of cotton lint	:Clemson, S. C.
FC-75	:Maintaining quality of rough rice during off-farm handling, conditioning and storage	:College Station, Tex.
FC-77	:Aflatoxin production in cottonseed	:College Station, Tex.
FC-78	:Basic factors in development of mycotoxins in peanuts and rice	:College Station, Tex.
FC-82A	:Relationship of fungi on corn to aflatoxin production and clinical diseases of livestock	:Lafayette, Ind.
FC-83	:Effects of improved handling, conditioning and storage on market quality of peanuts	:Dawson, Ga.
FC-84	:Objective measurements of market quality in raw peanuts	:Dawson, Ga.
FC-85*	:Rapid detection of molds and/or fungal metabolites in peanuts	:Dawson, Ga.
FC-88*	:Recovery of bacteria from heat injury	:Beltsville, Md.
FC-91	:Objective measurement of quality and physical characteristics of milled rice	:College Station, Tex.
FC-96PL	:The origin and characterization of mustiness in wheat	:Poznan, Poland
FC-97PL*	:Survey of growth of <u>Aspergillus flavus</u> and aflatoxins in cottonseed	:Hyderabad, India
FC-98PL	:Microflora and mycotoxins in stored sorghum, rice and groundnuts	:Mysore, India
FC-99PL	:Indicator organisms in dairy and food products	:Rajasthan, India
FC-101	:Measurement of drafting force and its variability under cotton processing operations	:Clemson, S. C.
FC-102*	:Inhibition of <u>Salmonella</u> and other bacteria in milk and dairy products by essential oils	:Beltsville, Md.
FC-102A	:Post mortem changes in quality and functional properties of bovine muscle proteins	:Stillwater, Okla.
FC-104C	:Detection of hidden-insect infestation in grain	:Kansas City, Mo.
FC-110A	:Microflora of flue-cured tobacco and their effect on quality	:Raleigh, N. C.
FC-113	:Development of a standard grain breakage test	:Manhattan, Kans.
FC-115	:Electrophoretic patterns of soluble proteins from bacteria	:Beltsville, Md.
FC-116	:Variation in yeast and its effect on the experimental baking test	:Beltsville, Md.
FC-117	:Design and development of an automatic grain sample divider	:Manhattan, Kans.
FC-118	:Identification of vegetable proteins added to meat products	:Beltsville, Md.

FC-119	:Changes in quality indicators as corn and : wheat are stored under various conditions	:Beltsville, Md. :
FC-120	:Mechanisms of fungus deterioration affecting : market quality of peanuts	:Dawson, Ga. :
FC-121	:Effect of cotton properties and residues on : fiber quality	:Clemson, S. C. :
FC-122	:Improving microbiological condition of : eviscerated broilers	:Athens, Ga. :
FC-123C	:Development of an automatic rice sizing device	:Baton Rouge, La.
FC-124	:Chemical and biological control of micro- : organisms in stored grains	:Manhattan, Kans. :
FC-125	:Accurate and rapid objective tests for : evaluating quality of bread crumb grain : and crumb color	:Beltsville, Md. : :
FC-126	:Microflora of tobacco and their effect on : quality	:Raleigh, N. C. :
FC-128	:Effect of cottonseed storage on oil quality	:Beltsville, Md.
FC-129	:Equipment to determine hidden-insect : infestation in grain	:College Station, Tex. :
FC-130C	:The fate of polyphenols in tobacco during air : curing	:Lexington, Ky. :
FC-131PL	:Assay methods, toxicology, biosynthesis, : incidence, production and control of : aflatoxins in grains	:Poznan, Poland : :
FC-132*	:Improved packing, shipping, and storage : methods for unfrozen poultry	:Beltsville, Md. :
FC-133	:Biochemical characteristics of fungal : metabolites	:Dawson, Ga. :
FC-134A	:Development of a method to determine general : appearance of grains	:Fargo, N. Dak. :
FC-135PL	:Occurrence of adipose, connective and fibrillar : tissues in muscles of slaughter animals	:Lublin, Poland :
FC-136	:Biochemical changes associated with seed : deterioration	:Beltsville, Md. :
FC-139	:Biochemical characterization of microbial : deterioration of meat	:Beltsville, Md. :
FC-140A	:Yield grade of lambs as related to quality : loss during storage and transit	:Beltsville, Md. :
FC-141C	:Composition and quality factors of imitation : milks	:Ithaca, N. Y. :
FC-142**	:Control and detection of salmonellae and : food poisoning microorganisms on meat	:Beltsville, Md. :
FC-143A	:Development of a laboratory device for : determining milling yield of rice	:College Station, Tex. :
FC-144	:Effect of commercial storage practices on : molds and aflatoxins in cottonseed	:Beltsville, Md. :
FC-145C	:Biological significance of aflatoxins in : tobacco and their decomposition products	:Lexington, Ky. :
FC-146PL	:Effect of growth promoters and inhibitors on : the synthesis of proteins in germinating : seeds	:Calcutta, India : :

FC-147C	:Determination of nitrogen by reduction with : hydrogen	:Baton Rouge, La. :
FC-148C	:Determination of nitrogen by oxidative : combustion	:Chicago, Ill. :
FC-149C	:Thermalanalytical studies of grain moisture	:Columbus, Ohio
FC-150	:Development of methods and techniques for : evaluation of market quality of oilseeds : and oilseed products	:Beltsville, Md. :
FC-151	:Study of nonaqueous volatile matter evolved : during oven moisture assay in grains	:Beltsville, Md. :
FC-152	:Improved method and device for determining : kernel hardness of grains	:Manhattan, Kans. :
FC-153	:Improving design and performance of mechanical : sampling devices	:Manhattan, Kans. :
FC-154	:Effect of physical/chemical properties of grain; : on deviations of electrical moisture meter : results	:Beltsville, Md. :
FC-155	:Development of mycotoxins during marketing : of sorghum grain in the Southwest	:College Station, Tex. :
FC-156	:Development of laboratory tests to determine : the most feasible procedure to remove : aflatoxin from specific lots of shelled : peanuts	:Raleigh, N. C. :
FC-158A	:The influence of eight distinctly different : body types of beef cattle on growth, body : composition and meat quality	:Madison, Wis. :
FC-159C	:Development of a Flat Bed Fiber Sampler	:Knoxville, Tenn.
FC-160C	:Modification of Cotton Fiber Strength Analyzer	:Dallas, Tex.
FC-161C	:Modification of Cotton Fiber Length Analyzer	:Dallas, Tex.
FC-162A	:Boneless meat yield of six major sow carcass : cuts and trimmed pork loins	:Madison, Wis. :
FC-163C	:Mycotoxins in relationship to tobacco and : health	:Lexington, Ky. :
FC-164C	:Development of a production prototype of an : automatic test weight device	:Kansas City, Mo. :
FC-165**	:Development of fiber and spinning quality : relationships for marketing cotton	:Clemson, S. C. :
FC-166**	:Cotton marketing system based on instrument : measurements of fiber quality	:Clemson, S. C. :
FC-167PL**	:Characteristics, handling performance and : end use suitability of Indian wools	:Bombay, India :
FC-168C	:Development of a device for weighing : individual kernels of grains	:Brookings, S. Dak. :
FC-169A	: <u>Salmonella</u> and fecal contamination of meat : during livestock slaughtering	:College Station, Tex. :
FC-170C	:Using microwave energy for determining : moisture of grains	:Kingsville, Tex. :
FC-171C	:Measuring mass of cotton fiber test specimen : in determining cotton fiber strength	:Knoxville, Tenn. :
FC-172C	:Influence of grass and of bark on spinning : performance of cotton	:Lubbock, Tex. :

FC-173PL	:Studies on the metabolism of <u>Aspergillus</u>	:Delhi, India
	: <u>flavus</u> with reference to the production of	:
	: aflatoxins	:
FC-174C	:Development of an objective method for classi-	:Chicago, Ill.
	: fying odors of grains	:
FC-175**	:Biochemical changes in raw peanuts related	:Raleigh, N. C.
	: to market quality	:
FC-176A**	:The effect of drafting systems on cotton	:Clemson, S. C.
	: market quality evaluation	:
FC-177**	:Development of rapid tests to aid in	:Beltsville, Md.
	: classification of wheat	:
FC-178**	:Control of Clostridia in packaged chilled	:Beltsville, Md.
	: poultry	:
FC-179PL**	:Investigation on the role of nucleic acids,	:Warsaw, Poland
	: nucleotides and natural inhibitors in the	:
	: process of seed germination	:
FC-180**	:Effects of handling, storage, and processing	:Dawson, Ga.
	: on the market quality properties of peanuts	:
	: and peanut products	:
FC-181A**	:Meat quality changes resulting from pre-rigor	:Stillwater, Okla.
	: muscle boning of bovine carcasses	:
FC-182A**	:Effect of pale, soft and exudative condition	:Ames, Iowa
	: on pork quality	:
FC-184**	:Post-mortem biochemical changes affecting	:Beltsville, Md.
	: meat quality	:
FC-187C**	:Feasibility of using pattern recognition in	:Lincoln, Nebr.
	: automatic grain grading	:
FC-188A**	:Blending and compacting grains and grain	:Manhattan, Kans.
	: products	:
FC-189C**	:The effect of microorganisms on biological	:Lexington, Ky.
	: activity of tobacco smoke	:
FC-191A**	:Standards for bacon quality	:Storrs, Conn.
FC-192A**	:Influence of additives on meat quality	:Amherst, Mass.
	: characteristics	:



HC-1	:Improved methods for storage of apples	:Beltsville, Md.
HC-2	:Treatments for control of postharvest rots and : functional disorders in apples and pears	: :Beltsville, Md.
HC-3	:Improved methods for storage of stone fruits	:Beltsville, Md.
HC-4	:Treatments for control of postharvest rots of : stone fruits	: :Beltsville, Md.
HC-5*	:Product requirements for storage and packaging : of selected root crops and leafy vegetables	: :Beltsville, Md.
HC-6	:Modified atmosphere effects on mature-green : tomatoes	: :Beltsville, Md.
HC-8	:Improved handling and storage of cut flowers, : bulbs, and plants	: :Beltsville, Md.
HC-9	:Reduced atmospheric pressure as affecting storage : life of tomatoes, bananas and berries	: :Beltsville, Md.
HC-11	:Objective methods for measuring maturity and : quality of apples	: :Beltsville, Md.
HC-13	:Objective measurement of maturity in mature-green : tomatoes	: :Beltsville, Md.
HC-14*	:Objective measurement of color of potato chips	:Beltsville, Md.
HC-16	:Treatments for control of postharvest decay of : onions	: :Belle Mead, N. J.
HC-17	:Role of fungal proteolytic enzymes in the death : of fruit and vegetable tissues	: :Belle Mead, N. J.
HC-18	:Identification and causes of market diseases of : fruits and vegetables	: :Belle Mead, N. J.
HC-19*	:Extent and nature of market losses of fruits and : vegetables	: :Belle Mead, N. J.
HC-23	:Identification and causes of market diseases of : fruits and vegetables	: :Chicago, Illinois
HC-25	:Treatments and environments for handling, storage : and transportation of potatoes and precut seed	: :E. Grand Forks, Minn
HC-26*	:Bruise injury and bruise injury susceptibility of : potatoes	: :E. Grand Forks, Minn
HC-27	:Protecting quality of fresh strawberries during : air or surface transportation	: :Fresno, California
HC-28	:Heat pasteurization and fungicides for control : of decay of strawberries, figs and grapes	: :Fresno, California
HC-29*	:Effects of weather and field diseases on post- : harvest quality of lettuce and melons	: :Fresno, California
HC-30*	:Effects of controlled atmospheres and heat on : the activity of decay organisms	: :Fresno, California
HC-31*	:Controlled atmosphere effects on cauliflower, : radish, asparagus and broccoli	: :Fresno, California
HC-34	:Improved handling and storage of cut flowers and : ornamental plants	: :Fresno, California
HC-37	:Extending the market life of Texas grapefruit in : foreign markets	: :Weslaco, Texas
HC-38	:Improved methods for storage of subtropical fruits	:Miami, Florida

HC-41	:Improved methods for storage of Florida citrus fruits	:Orlando, Florida
HC-42	:Control of postharvest rots in Florida citrus fruits	:Orlando, Florida
HC-45	:Improved methods for storage of California oranges : and lemons	: :Pomona, California
HC-46*	:Modified atmosphere effects on the growth of citrus : decay organisms	: :Pomona, California
HC-47	:Citrus volatiles as a measure of market quality : during storage	: :Pomona, California
HC-48	:Extending the market life of California citrus : fruits in foreign markets	: :Pomona, California
HC-49	:Methods for handling and storage of precut seed : potatoes	: :Presque Isle, Me.
HC-50	:Improved prestorage and storage treatments for : reduction of wastage in potatoes	: :Presque Isle, Me.
HC-51	:Composition of blueberries as related to incidence : of postharvest decay	: :Raleigh, N. C.
HC-52	:Improved methods for handling and storing sweet- : potatoes	: :Raleigh, N. C.
HC-53	:Objective methods for measuring maturity and quality : of apples	: :Wenatchee, Wash.
HC-55	:Relationship between preharvest environment and : postharvest quality in apples and pears	: :Wenatchee, Wash.
HC-57A	:Relation between preharvest environment and post- : harvest quality in apples and pears	:Oregon State Univ. :Corvallis, Oregon
HC-60A	:Modified atmosphere effects on celery, sweet corn : and tomatoes	:Univ. of California :Davis, California
HC-63PL	:Metabolic changes during storage and ripening of : mangos	:Univ. of Baroda :Baroda, India
HC-68	:Storage and marketing of <u>Actinidia chinensis</u> : (Chinese gooseberry)	: :Fresno, California
HC-69	:Improved precooling methods for grapes and straw- : berries	: :Fresno, California
HC-70*	:Maintenance of cut flower color after harvest	:Bradenton, Florida
HC-71	:Improving the keeping quality of Florida-grown : cut flowers	: :Bradenton, Florida
HC-72C	:Toxicity and carcinogenicity of diphenylamine to : mice	:Albany Medical College :Albany, New York
HC-73A	:Market quality of citrus fruits as related to : mechanical harvesting	:Univ. of Florida :Lake Alfred, Fla.
HC-75	:Thermotherapy and chemotherapy for control of : postharvest decay of stone fruits	: :Fresno, California
HC-76*	:Objective methods for measuring firmness of head : lettuce	: :Beltsville, Maryland
HC-77	:Identification of the virulence enzymes in phyto- : pathogenic soft rot bacteria and fungi	: :Chicago, Illinois
HC-78	:Improved handling, cooling and shipping practices : for lettuce and celery	: :Fresno, California
HC-79	:Evaluation of instrument measurement of delayed : light emission (DLE) and chlorophyll content of : raw tomato juice	: :Beltsville, Maryland

HC-80	:Quality and losses of exported U.S. agricultural : commodities in Europe	: :Rotterdam, Netherlands
HC-81	:In-store prepack and consumer losses of selected : fresh fruits and vegetables in the Chicago market	: :Chicago, Illinois
HC-82	:Development of improved methods of degreening : citrus fruits	: :Orlando, Florida
HC-83	:The effects of mechanical harvesting and packing- : house systems on vegetable damage and postharvest : decay	: : :Orlando, Florida
HC-84PL	:Biosynthesis and mode of action of ethylene in : fruits	: :Beit Dagan, Israel
HC-85PL	:Postharvest behavior of apples and pears	:Ljubljana, Yugoslavia
HC-86	:Control of scald on apples and pears	:Wenatchee, Wash.
HC-87	:Chemical and non-chemical control of postharvest : rots of western apples and pears	: :Wenatchee, Wash.
HC-88**	:Biochemical changes in citrus fruit stored in air, : low O <sub>2</sub> and high CO <sub>2</sub> atmospheres	: :Orlando, Florida
HC-89A*	:Fungi and possible mycotoxins associated with pecans : in storage	:Univ. of Georgia :Athens, Georgia
HC-90A*	:Quality maintenance of mechanically harvested : horticultural crops	:Clemson University :Clemson, S. C.
HC-91**	:Market quality of Texas citrus as related to tree : fertilization, growth regulators, fungicides and : degreening	: : :Weslaco, Texas
HC-92**	:Development of non-destructive objective maturity : indices for cantaloups	: :Beltsville, Md.
HC-93**	:The evaluation of damage to potatoes by bulk dry : handling equipment	: :E. Grand Forks, Minn.
HC-94**	:Effects of nutrition, inoculum density and CA on : the pathogenesis of decay organisms affecting : fruits, vegetables and flowers	: : :Fresno, California
HC-95**	:Losses in selected fruits and vegetables at retail : and consumer levels in the Greater NY market	: :Belle Mead, N. J.



SP-2PL	:Lipids and their metabolism in relation to DDT resistance by <u>Trogoderma granarium</u> .	:Univ. of Delhi :Delhi, India
SP-3PL	:Legume seed components as beneficial and detrimental factors in insect and animal nutrition.	:U. of Jerusalem :Rehovot, Israel
SP-6A	:Residual insect-control treatments for food-processing facilities and storage areas.	:Univ. of Wis. :Madison, Wis.
SP-7	:Preventing insect damage to dairy products in marketing channels.	:Madison, Wis. :
SP-15PL	:Ecological studies and fumigation of <u>Trogoderma granarium</u> .	:Punjab Agric. U. :Ludhiana, India
SP-16	:Preventing insect damage to tobacco and tobacco products in marketing channels.	:Richmond, Va. :
SP-18G*	:Comparative life histories and bionomics of <u>Trogoderma</u> species.	:Univ. of Calif. :Riverside, Calif.
SP-25A*	:Insect-bulgar relationships affected by environmental factors including fumigation.	:Kans. State U. :Manhattan, Kans.
SP-27A	:Water regulation physiology and stress in stored-product insects.	:Kansas State U. :Manhattan, Kans.
SP-28A	:Association of insects to dangerous microorganisms in stored grains.	:Kans. State U. :Manhattan, Kans.
SP-32A	:Endocrinology of reproduction in <u>Sitophilus</u> sp.	:Clemson, S. C.
SP-33A	:Effects of parasites and predators on population dynamics of Indian-meal moth.	:Clemson Univ. :Clemson, S. C.
SP-34A	:Fate of malathion residues on grain sorghums.	:Manhattan, Kans.
SP-36A	:Role of quinones in regulating populations of confused flour beetle, <u>Tribolium confusum</u> .	:Cornell Univ. :Ithaca, N. Y.
SP-37A*	:Morphological and taxonomic characters of immature stages of <u>Carpophilus</u> beetles.	:Calif. Dept. of Agr. :Sacramento, Calif.
SP-38PL*	:Varietal resistance of wheat to rice weevil and lesser grain borer.	:Ind. Agric. Inst. :New Delhi, India
SP-40PL*	:Use of antimetabolites for the control of certain stored-product insects.	:Hebrew Univ. of :Jerusalem, Israel
SP-41PL	:Role of active substances produced by the khapra beetle in mixed populations of stored insects.	:Hebrew Univ. of :Jerusalem, Israel
SP-44PL	:Ecology of mites attacking dried fruits and herbs.	:Warsaw Agric. Univ. :Warsaw, Poland
SP-45PL	:Effect of inert dusts, insect pathogens, temperature and humidity on stored-product insects.	:Univ. of Zagreb :Zagreb, Yugoslavia
SP-46	:Preventing insect damage to dried fruits in marketing channels.	:Fresno, Calif. :
SP-47	:Preventing insect damage to tree-nuts in marketing channels.	:Fresno, Calif. :
SP-48	:Preventing insect damage to rice and rice products in marketing channels.	:Beaumont, Tex. :
SP-49	:Preventing insect damage to wheat and wheat products in marketing channels.	:Manhattan, Kans. :



SP-50	:Preventing insect damage in the mid-west to corn :and corn products in marketing channels.	:Manhattan, Kans. :
SP-51	:Preventing insect damage to grain sorghums in :marketing channels.	:Manhattan, Kans. :
SP-52	:Preventing insect damage in the South to corn :and corn products in marketing channels.	:Tifton, Ga. :
SP-53	:Preventing insect damage to farmers stock :peanuts in marketing channels.	:Tifton, Ga. :
SP-54PL	:Role of amino acids and vitamins in the physi- :ology of certain stored-product insects.	:U. of Rajasthan :Rajasthan, India
SP-55	:Evaluation of chemicals to protect wool, hair :and feathers from insects.	:Savannah, Ga. :
SP-56	:Controlled atmospheres for protecting stored :products against insect damage.	:Savannah, Ga. :
SP-57	:Detecting and controlling stored-product insects :with sound, light and near-visual light.	:Savannah, Ga. :
SP-58	:Gamma radiation effects on insects and develop- :ment of treatments for grains and packaged foods.	:Savannah, Ga. :
SP-59	:Develop insect-resistant packages using paper, :paperboard, plastics and other materials.	:Savannah, Ga. :
SP-60	:Develop insect-resistant cotton bags.	:Savannah, Ga.
SP-61	:Evaluation and development of insecticides to :control insects in foods and feeds in marketing :channels.	:Savannah, Ga. :
SP-62	:Insecticide residues from experimental treatments :to prevent or control insects in stored products.	:Savannah, Ga. :
SP-63	:Detection of hidden insect infestations in grain.	:Savannah, Ga.
SP-64	:Morphology and function of stored-product insect :sensory receptors.	:Savannah, Ga. :
SP-65*	:Mitochondrial metabolism during development of :Indian-meal moth.	:Savannah, Ga. :
SP-66	:Effect of photoperiod and temperature on Indian- :meal moth.	:Savannah, Ga. :
SP-67	:Effect of humidity on behavior of <u>Oryzaephilus</u> : <u>surinamensis</u> and <u>O. mercator</u> .	:Savannah, Ga. :
SP-68PL	:Stored grain insect pests and their control in :Uttar Pradesh, India.	:Uttar Prad. U. :Nainital, India
SP-69PL	:Effect of legume seed components on digestive :and endocrine system of certain insects, chicks :and rats.	:Inst. Biol. Res. :Belgrade, :Yugoslavia
SP-70PL	:Mechanism of action of halogenated hydrocarbon :fumigants on animals.	:Hebrew Univ. :Rehovot, Israel
SP-71A	:Isolation and characterization of insect phero- :mones of the cigarette beetle, <u>Lasioderma</u> : <u>serricornis</u> (F.).	:Univ. of Wis. :Madison, Wis. :
SP-75A	:Investigations of masking of sex attractants of :stored-product insects.	:Univ. of Ga. :Athens, Ga.

SP-76	:Temperature for protecting stored products :against insect damage.	:Savannah, Ga. :
SP-77	:Chemical constituents of natural foods for con- :trolling stored-product insects.	:Savannah, Ga. :
SP-78	:Microbial control of insects attacking stored :products in marketing channels.	:Fresno, Calif. :
SP-79PL	:Application of gamma rays for the control of :some major stored-grain pests.	:Min.Food & Agric. :West-Pakistan
SP-80PL	:Control of khapra beetle ( <u>Trogoderma granarium</u> ).	:West-Pakistan
SP-81	:Basic research on biology, ecology, physiology, :and nutrition of stored-product insects.	:Gainesville, Fla. :
SP-82A	:Determination of chemical components of plants :resistant to stored-product insects.	:Univ. of Ga. :Athens, Ga.
SP-83A*	:Morphology and chemistry of the odiferous glands :of the lesser mealworm.	:Univ. of Md. :College Park, Md.
SP-84A	:Degradation products and metabolites of BAY :77488 on wheat.	:Kans. State U. :Manhattan, Kans.
SP-85A	:Control of stored-product insects with anti- :microbial agents and food preservatives.	:Univ. of Wis. :Madison, Wis.
SP-86	:Reducing losses caused by insects in harvested :soybeans throughout the marketing channels.	:Manhattan, Kans. :
SP-88A	:Basic research on pheromones, hormones, and :enzyme systems in stored-product insects.	:Univ. of Fla. :Gainesville, Fla.
SP-89A	:Sex attractants of selected stored-product :lepidopterous pests.	:Univ. of Ga. :Athens, Ga.
SP-90A	:Effect of environmental factors on food consump- :tion and utilization by stored-grain insects.	:Univ. of Ill. :Urbana, Ill.
SP-91A	:Attractant studies with <u>Trogoderma glabrum</u> .	:Syracuse, N. Y.
SP-92PL	:Dosage compensation and its genetic implications :on the pest of stored grains, <u>Sitophilus oryzae</u> :(L.).	:U. of Calcutta :Calcutta, India :
SP-93PL**	:Scheme for research on stored grain pests in :West Pakistan.	:W. Pakistan U. :W. Pakis., India
SP-94PL**	:Search for sex and food attractants in <u>Trogoderma</u> : <u>granarium</u> and <u>T. glabrum</u> .	:Israel Inst. :Ness-Ziona, Israel
SP-95**	:Endogeneous control mechanisms governing the :accumulation and utilization of nutrients during :the growth and development of Indian-meal moths.	:Gainesville, Fla. :
SP-96**	:Physiological effects of extraneous manipulation :of hormonal balance during the growth and devel- :opment of Indian-meal moths.	:Gainesville, Fla. :
SP-97**	:Isolate and identify sex pheromones of stored- :product insects and determine their biological :and behavioral characteristics.	:Gainesville, Fla. :
SP-98**	:Bionomics and control of stored-product insects :in export commodities, carriers, and facilities.	:Beaumont, Tex. :

SP-100**	:Control of the navel orangeworm, <u>Paramyelois</u>	:Fresno, Calif.
	: <u>transitella</u> (Walker), as a pest of almonds prior :	
	:to harvest and in marketing channels.	:
SP-101A**	:Low level electromagnetic frequency effects on	:Univ. of Idaho
	:stored-product insects.	:Moscow, Idaho
CL-1	:Color measurement and appearance evaluation of	:Beltsville, Md.
	:agricultural products	:
PL-1	:Biosynthesis and role of ethylene in plant tissue	:Beltsville, Md.
PL-2	:Ultrastructure and function in the fruit all	:Beltsville, Md.
	:during maturation and senescence	:
IL-3G	:Electrical properties of fruits and vegetables	:Lafayette, Ind.
IL-4A	:High intensity optical system to measure light	:Lafayette, Ind.
	:transmittance properties	:
IL-5A	:Application of attenuated total reflectance	:College Park, Md.
	:technique to quality evaluation	:
IL-6	:Development of instruments to measure the quality	:Beltsville, Md.
	:of agricultural commodities	:
IL-7C	:Automatic sorting of apples for interior quality	:Rockville, Md.
	:by light transmittance	:





Architect's rendition of the new Stored Product Insects Research and Development Laboratory, Savannah, Georgia



Horticultural Field Station, Orlando, Florida, housing the Southeastern Citrus and Vegetable Investigations





Grain Marketing Research Center, Manhattan, Kansas, housing the Grain Quality and Sampling Investigations and the Midwest Grain Insects Investigations



Gulf Coast Citrus and Vegetable Investigations, Weslaco, Texas



Insect Attractants, Behavior and Basic Biology Laboratory, Gainesville, Florida











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